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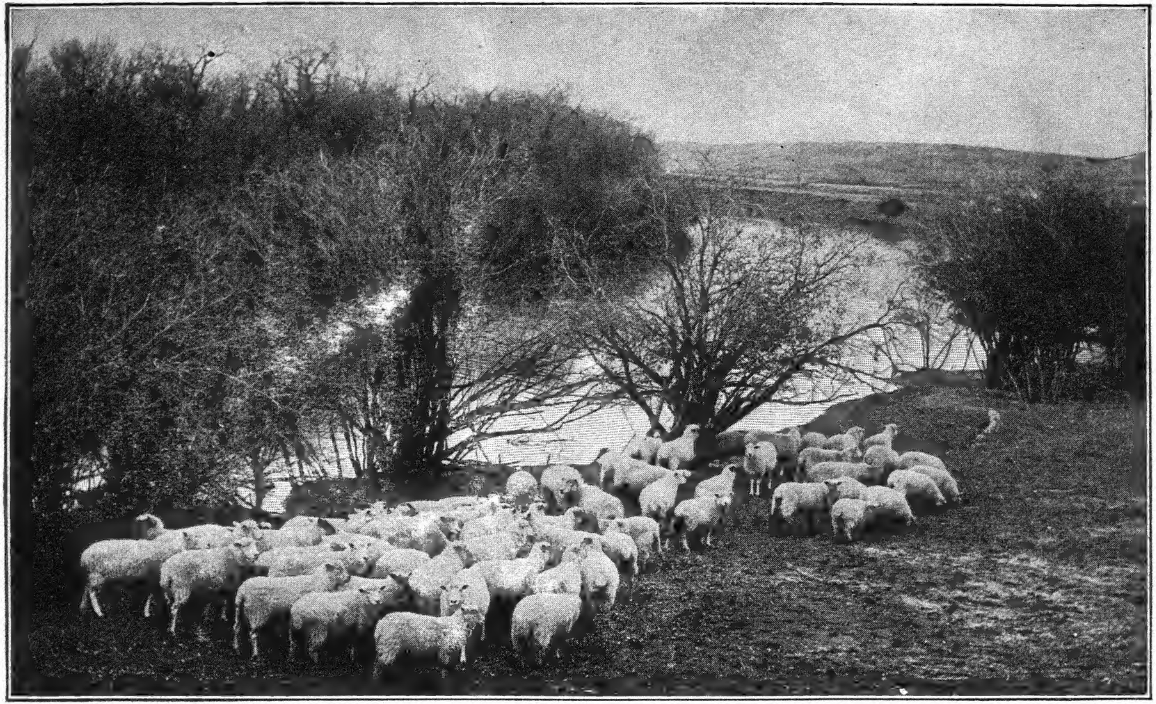

Raising sheep under ideal conditions on the Prairie

PRAIRIE AGRICULTURE

FOR

HIGH SCHOOLS

BY

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PREFACE

Up to the present there has not been a text in which the principles and practices of agriculture, applicable to conditions in the Prairie Provinces of Canada, were satisfactorily presented to students of High Schools and Collegiate Institutes. This book has been written with this purpose in view. The subject has not been treated from a strictly vocational standpoint, although every effort has been made to discuss the problems and operations of the farm in as practical and helpful a manner as possible, and the topics which offer the greatest opportunities for the development of the student have been emphasized.

Stress has been placed on the principles underlying a permanent system of agriculture, and it is hoped that the student who intends to engage in agricultural activities will find many suggestions of real value to him in actual practice. A serious attempt has been made, as well, to catch the interest of other students, and to acquaint them with the fundamentals of our basic industry. The student who, even in a small way, is familiar with the problems and difficulties confronting the farmer will be better equipped to take his place in whatever sphere of activity he may in the future find himself in Western Canada, an essentially agricultural community.

The author wishes to express his appreciation of the cooperation and helpful criticism of Mr. G. B. Walker, formerly of The School of Agriculture, Claresholm, Alberta; Professor V. W. Jackson, Manitoba Agricultural College; Dr. G. B. Stillwell, Department of Education, Regina; Mr. C. A. Edwards, Tree Planting Division, Indian Head, Saskatchewan; Mr. A. J. Clark, formerly of the Live Stock

Branch, Regina; Mr. A. Hodgkins and Mr. T. W. Hunt, Regina Collegiate Institutes; Mr. A. R. Brown, Provincial Normal School, Saskatoon; Mr. W. H. Boyle and Mr. S. Einarsson, Regina; Mr. O. D. Davidson, formerly of the Moose Jaw Collegiates; and Mr. M. P. Tullis, Mr. W. Waldron, Mr. P. E. Reed, and Mr. J. H. Ross, Department of Agriculture, Regina. Valuable suggestions have been gathered from other agricultural texts, and free use has been made of the information available in various government publications. The author desires to acknowledge the assistance received from these sources.

A great deal has been added to the value and attractiveness of the book by the use of many illustrations loaned by the Publications Branch, and *The Grain Growers' Guide*, Winnipeg; The Seed Branch and The Entomological Branch, Department of Agriculture, Ottawa; The Live Stock Branch and The International Harvester Company, Regina, and the Massey-Harris Company, Toronto. Thanks are also due to others who have generously supplied illustrations which are acknowledged as they appear in the text.

A few of the drawings are in part copies from the works of other authors, but the majority are original and have been drawn especially for this book.

H.C.A.

Regina, Saskatchewan,
March, 1927.

SUGGESTIONS TO TEACHERS

This book has been written as a combination text and manual. Problems and experiments have been used to elaborate topics or emphasize points already discussed. This must at all times be kept in mind by the teacher, and no part of the book must be considered completely covered until all exercises have been performed and thoroughly studied in relation to the topic to which they refer. A number of projects have been outlined, and others will suggest themselves to the teacher. Several of these should be selected each term for the students to perform with the consent and co-operation of their parents. All work in agriculture must be arranged so that those parts which are seasonable may be taken up at the appropriate time.

Agriculture will become an important educational subject only when teachers require the students to make more accurate and detailed observations and to record their observations, neatly and concisely, in suitable note-books. Experiments should be written up, by junior students at least, under the following five headings: object, apparatus and material, procedure, observations, and conclusions. Simple descriptive diagrams will be found to be valuable teaching aids whenever a topic can be illustrated. The students' written reports of all but a few of the simplest exercises should be accompanied by a cross-sectional diagram of the apparatus, drawn in more than one color, all parts named, and the result of the experiment shown if possible. All drawings marked (Draw.) in the text should be neatly reproduced by the students, who should use their own specimens from which to draw. Good-sized, simple, outline drawings, without shading, are best.

The success of teaching depends, after all, upon the teacher. Every effort must be made to relate the work of the school to the everyday life of the student. In a text on general agriculture it is not possible to deal with all of the facts of the subject—only a few of the fundamentals can be outlined. The teacher must be responsible for discussions of local practices and should not fail to learn the varieties of grain, breeds of live stock, methods of tillage, etc., which predominate in and are most suitable for the district around the school. It is not intended that all of the material in this book should be taken up in every school of the three Prairie Provinces. The

outline in the *Programme of Studies* prepared by each Department of Education must be the teacher's guide in the organization of his lessons. It is also essential that both teacher and student should carefully watch newspapers and magazines for announcements referring to the advancement of agriculture. Even as this text is being written a notice appears of two new varieties of wheat, Garnet and Reward. Such information as this must be noted.

The name of every school should be on the mailing list of the Publications Branch, Department of Agriculture, Ottawa. In attending to this the teacher is advised to ask particularly for the *List of Publications* bulletin and for the periodic notices of new publications. From these lists bulletins and pamphlets can be selected that deal with the topics discussed in this book and with other phases of agriculture that may be of special interest to some of the students. The school library should contain at least one copy of these bulletins, and the students should be encouraged to read them. A very helpful bulletin is *Seasonable Hints, Prairie Edition,* which is published in March, July, and November of each year. This and the other bulletins mentioned above may be obtained, free of charge, by applying to the Publications Branch. Letters of application require no postage.

The author will welcome suggestions from teachers and others.

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HIGH SCHOOL AGRICULTURE

CHAPTER I

THE SOIL

"The soil is not only the foundation of agriculture, but it is also the basis of all human prosperity. It is the most common and yet the most precious thing in all the world."—*Harris and Stewart.*

The soil is usually defined as the mixture of fine loose rock material and vegetable matter that covers the solid part of the earth and in which plants find a foothold and certain food materials. The depth of soil covering the bed-rock varies from a few inches to many feet. In some places there is no soil, the rocks being entirely bare.

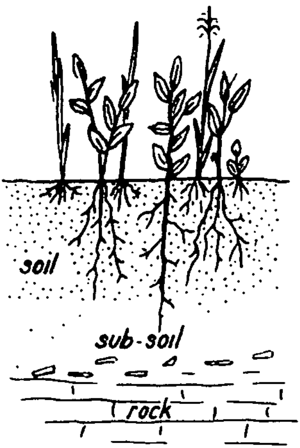
Origin and Formation.—Soils have been formed by the weathering or crumbling of the solid rock that originally covered the surface of the earth. Through long centuries many agencies have been at work reducing the rocks to fine particles. Water, by dissolving, eroding, and many other methods of attack, probably plays the most important part in this great process. The contraction and expansion of the rocks, through the winters and summers of many ages, finally breaks them apart. Carbon dioxide from the air unites with water to form an acid that attacks the rocks. Glaciers, frost, wind, plants and animals, and many other agencies all help in the great work of slowly but surely reducing the rocks to soil.

There are many kinds of soil, and each has been formed in a different manner and from different kinds of rocks. Many soils have been transported by wind or water long

distances from where they were originally formed. Most of the soils in Western Canada did not originate where they are now found, but have been brought from other parts of the country chiefly by rivers and glaciers.

Project.—Make a study of the soil and rock formation of your district. How do you account for the muddy appearance of most of our rivers?

Surface Soil and Sub-soil.—The surface soil is the top layer, usually five or six inches deep, which is cultivated and in which seeds are planted. The sub-soil is below the top soil and may extend from two or three to many feet in depth.



Soil, sub-soil, and bed-rock. (Draw.)

Exercises.—(1) Examine the walls of an excavation for a cellar or well. Observe the difference between the surface soil and the sub-soil with reference to fineness, color, number of roots, etc. Is the line between the two soils distinct?

(2) Which is the most exposed to weathering influences?

(3) Which will contain the most humus? Give reasons for your answer.

(4) Enquire of farmers the nature of the sub-soil in your locality.

Over 90 per cent of the feeding roots of plants are found within the upper parts of the soil; consequently the surface soil will contain more humus and be darker in color than the soil below. For the same reason it is usually better aerated and has greater water-holding power. It is also finer in texture and in general more productive. In some parts of Western Canada these differences between the surface and the sub-soil are less clearly defined, while in other

localities a very black top soil will be found above a sub-soil that is almost white.

Importance of the Sub-soil in Crop Production.—A careful examination of the sub-soil must be made before a soil is selected for the growing of crops. An impervious sub-soil will result in poor drainage. On the other hand, moisture will escape too readily through a sub-soil that is loose and coarse. Either condition, or a sub-soil very low in available plant food, confines the productive region of the soil to the top few inches and is unsatisfactory for agricultural purposes.

It is sometimes possible by occasionally plowing deeper than the usual furrow slice to replenish the fertility of the top soil by bringing up new material from the sub-soil. The nature of the sub-soil must be carefully considered before this practice is attempted. Turning up a sub-soil lacking in fertility would do more harm than good.

Composition of the Soil.—(*a*) **Chemical Composition.**

Exercises.—(1) Remove a sample of ordinary soil from field or garden. Allow it to become thoroughly dry. Place it in a crucible and weigh. Heat intensely until all dark color is removed, and reweigh. The difference in weight is the amount of *organic matter* or *humus* in the soil.

(2) Thoroughly mix a sample and place in an evaporating dish. Moisten and stir to form a thick paste. Carefully by means of clean forceps lay strips of red and blue litmus paper over the surface and gently press them into close contact with the soil. If the blue litmus paper turns red, the presence of an *acid* in the soil is indicated. If the red litmus paper turns blue, it indicates the presence of alkali.

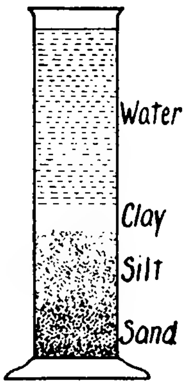
(3) Place about 1½ inches of common soil in an ordinary sized test-tube. Fill the test-tube ¾ full of distilled or rain water. Boil vigorously for 5 or 10 minutes. It may be necessary to stir the soil with a wire or glass rod several times until the water starts to boil. Add a small amount of nitric acid and cool. A yellow color indicates the presence of organic *nitrogen*.

(4) The tests for inorganic nitrogen and for the other essential plant food elements may be found in any chemistry text but are not recommended for junior students.

(5) Place a small quantity of soil in a flask. Insert into the mouth of the flask a two-holed rubber stopper in which a thistle-tube and a bent glass delivery-tube have been previously placed. Pour in sufficient water to cover the soil and the end of the thistle-tube. Attach a rubber tube to the glass delivery-tube. Pour a small amount of hydrochloric acid down the thistle-tube, and, when gas begins to come from the soil, pass it through lime-water by means of the rubber tube. If the lime-water turns milky, it indicates that carbon dioxide has been liberated from the soil by the acid. This proves that the soil contains a *carbonate salt.*

(*b*) **Physical Composition.**

(6) Place about 3 inches of sandy soil in a 200 c.c. graduate jar or other tall, slender glass vessel. Hold the hand over the open end and shake vigorously until all lumps in the soil are thoroughly broken up. Then set on a table and allow to settle. Examine in a few minutes and mark the height of the settled particles. Do the same in an hour and after several hours. It should now be noticed that the soil has been separated in three parts. The coarser particles, which settled to the bottom in a few minutes, are *sand.* The finer particles, which settled in an hour, are *silt.* The very fine grains, which remained in suspension in the water several hours, are *clay.*



An experiment to learn the composition of soil. (Draw.)

(7) Make a drawing of the above experiment, and label the different soil separates.

In making the foregoing tests the class might be divided into several groups. Each group should collect and test samples of soil from various parts of the district. Afterwards the class should assemble with the teacher to compare and summarize results. Make tests of sub-soils as well.

The first of the foregoing experiments demonstrates that, although soil is composed to a large extent of fine rock material, it is not all mineral matter. The part of the soil that burns is called *humus* or *organic matter.* The humus

is composed of decayed vegetable or animal material. If you examine the soil closely, you will find bits of roots, leaves, and stems. These will be in various stages of decay and are called *fibre*. When more fully decayed, they form humus. Humus is dark in color, and it has been found that it absorbs heat rapidly and is an important factor in improving the water-holding power of the soil. It also is the source of nitrogen in the soil. The fact is that a soil with little or no humus is useless for the production of crops. The fibre in the soil prevents drifting or blowing because it binds the particles of soil together.

Exercise No. 6 demonstrates that there are coarse and fine *particles* or *grains* in the soil. The particles are classified according to size as follows:

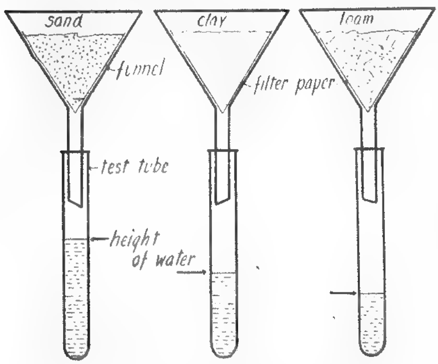
Fine Gravel..........	2 —1 millimetres.
Coarse Sand.... ...	1 —.5 millimetres.
Medium Sand.........	.5 —.25 millimetres.
Fine Sand............	.25—.10 millimetres.
Very Fine Sand........	.10—.05 millimetres.
Silt..................	.05—.005 millimetres.
Clay.................	Smaller than .005 millimetres.

The sand, silt, and clay contain potassium, phosphorus, iron, sulphur, calcium, etc. Sand, which is formed largely from a mineral called quartz, is glassy in appearance, heats and cools quickly, and makes the soil loose and open. The clay is formed chiefly from a mineral called feldspar and, because it is much finer than sand, causes a soil to be sticky and inclined to become hard and baked. Clay heats and cools slowly and has high water-holding power.

Exercises.—(1) Weigh equal volumes of dry sand, clay, and humus (leaf mold). Compare their weights.

(2) Moisten and make a ball of sand and of clay. When thoroughly dry, compare the looseness of the two samples.

(3) On a warm day expose to the sun some sand and clay. After a time thrust the bulb of a thermometer just below the surface of each sample and compare the temperatures.



An experiment to determine which soil has the greatest water-holding power. (Draw.)

(4) Place equal amounts of sand, clay, and a soil containing a percentage of humus in filter papers fitted into funnels. Insert the stems of the funnels into equal sized test-tubes. Pour $\frac{3}{4}$ of a test-tube of water through each sample. Observe the amount of water in the test-tubes below the funnels. Which sample has retained the most moisture? Draw a diagram to show clearly the result of this experiment. Account for the water-holding capacity of sand, clay, and loam.

Soil Texture and Structure.—The term *texture* refers to the size of the soil particles. If the particles are large, as in sandy soils, the soil is said to have a coarse texture. Clay soils are fine in texture. Why? Will texture influence the water-holding power of a soil, the amount of air in it, or the ease with which it may be plowed?

Exercise.—Spread several samples of soil thinly on a piece of paper. Observe whether the particles are single or in groups.

The arrangement of the soil particles in groups is known as the *structure* of the soil. It will be seen from the foregoing exercise that in most soils the particles are bound together in groups or *granules*. When the structure of the soil is fine and loose so that the soil is in the best condition for planting seeds, the soil is said to be *friable* and in *good tilth*. Soil in poor tilth is either lumpy or too fine.

Porosity or Pore Space.—Since the soil particles do not lie close together, there must be a great deal of space

between them. It has been found that under ordinary field conditions from 40 to 60 per cent of the total volume of the soil is space. This pore space is important as it determines the amount of water or air that may enter a soil.

Exercises.—(1) Place equal volumes of sand and clay in beakers. Pour water on the samples, keeping an accurate record of the amount of water that each will absorb. Where does the water go to as it soaks into the sand and clay? What does this experiment indicate about the porosity of sand and clay?

(2) What influence will texture and structure have upon the amount of pore space in a soil?

(3) Sandy soils are more porous than clay soils but have less total pore space. Explain.

Soil Air.—**Exercise.**—Place a small dish of soil quickly under water. Observe the air bubbles that rise out of the soil.

Air in the soil is essential to plant life. Oxygen is necessary for the germination of seeds, the growth of roots, and the functioning of beneficial bacteria. By cultivating the soil we break and loosen it up and allow the air to enter. By this means impurities in the soil are oxidized and changed into harmless substances, the formation of injurious acids is prevented, and the soil is maintained in a sweet growth-promoting condition. Of course, too much air is likely to dry out the soil. Each kind of soil must be treated differently in this respect. Sandy soils are apt to contain too much air, while it is often difficult to maintain the proper amount in soils of a clay nature.

Soil Temperature.—Seeds germinate best at a temperature of from 35° to 70° Fahrenheit. The soil must be managed so that it heats to this temperature early in the spring in order to germinate the crops as soon as possible. Damp, poorly drained soils will be cold. Well-tilled soils will be warm. Dark-colored soil usually heats quickly and remains warm. Why? How will sandy and clay soils

compare in temperature? The heat in the soil is received chiefly from the sun or warm rains. Some heat will be produced in the soil by such chemical action as the decay of plants.

Color.—The color of the soil depends upon the ingredients which compose it. If the soils are chiefly sand or clay, they will be light in color. When a good supply of humus or organic matter is present, soils will be dark. It is not difficult to see, then, that we could safely judge a light-colored soil to be lacking in richness. Besides containing more food for plants, dark-colored soils will hold water better and warm up more quickly, and should therefore be chosen as best for producing crops.

Soil Moisture.—Rainfall.—Moisture is essential in many life processes of the plant. No food is taken in by the plant from the soil until first dissolved in water.

Exercises.—(1) Drop a handful of fresh soil into a glass of distilled water. Stir well, then filter the water into an evaporating dish. Evaporate to dryness. In the bottom of the dish you will find a dark precipitate. What is your conclusion?

The best soils are useless without moisture. Practically all of the enormous quantity of moisture required by the plant is secured from the soil, which must act as a storehouse for water and supply it to the plant when most needed.

(2) Estimate the inches of rainfall required to produce 20 bushels of wheat. An acre inch of water weighs 100 tons. In wheat 700 pounds of water are required to produce 1 pound of dry matter. The kernels and straw, when ripe, will be about 85% dry matter, and $\frac{1}{2}$ the dry matter will be stems and leaves (straw). A bushel of wheat weighs 60 pounds. Think over the facts given in this problem. Much more rain than actually required must fall because there is much loss due to run-off, seepage, evaporation, and weeds.

In most parts of Western Canada the chief sources of soil moisture are rain and snow. If the rainfall fails, there

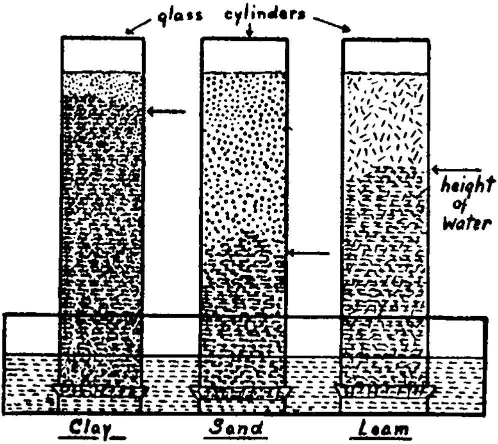
is no crop. Nothing can be done to increase the precipitation, but much can be accomplished to catch and store up the moisture that does fall. The average annual precipitation in Western Canada is from 13 to 20 inches, of which 50 per cent falls during May, June, July, and August. What is the average rainfall in your district?

Kinds of Soil Moisture.—*Gravitational or free moisture.*—After a heavy rainfall, when the soil has become saturated, a part of the water soaks rapidly down through the soil or runs off over the surface. Because this moisture is not held by the soil, but responds readily to the pull of gravity, it is called gravitational or free moisture. It is not used by plants but is often injurious to them, as it fills up the pore spaces of the soil and drives out the air. If we dig down into the soil, we can usually come to free water, such as is the case in sinking a well. The level at which this free water is found is known as the *water table*, and may be but a few inches or many hundreds of feet below the surface.

Capillary moisture.—As the upper layers of soil become dry, water from below will, if the soil is in good tilth, rise by capillary action to effect a remedy. To understand how this occurs it is necessary only to observe the rise of oil in a wick, or the soaking of ink into a blotter. These and the ascension of water in the soil are similar processes. As the capillary moisture pushes its way upward, thin films of water gather around the soil particles. When downward movements take place, this film moisture maintains its position, and, in this way, large quantities of water are held up in the soil. Roots coming in contact with capillary or film moisture absorb it, and it is therefore the *available soil moisture.* When the soil is in a fine condition, horizontal movements of moisture may occur as the films of water pass readily from moist to dry particles of soil. To maintain a good supply of moisture, well distributed through-

out the soil and in the most available form, it is quite obvious that the soil must be maintained in a thoroughly pulverized state. Capillary rise of moisture in the soil depends upon the size and the compactness of the soil particles.

Exercises.—(1) Take several lamp chimneys (deeper glass cylinders are better if available). Tie a piece of cheese-cloth over the bottom of each. Fill one with sandy soil, another with clay soil, and so on. Place the chimneys in a vessel of water, and observe in which soil the water rises most quickly. The moisture should rise quickest through sand, next in loam, and slowest but highest in clay. Draw a descriptive diagram of this experiment. Label each kind of soil. Mark in each case the height to which the water rose. Explain each result.



An experiment to determine the rise of capillary moisture through different kinds of soil. (Draw.)

(2) Fill a tumbler with very small marbles or shot. Notice the spaces between. Fill the glass with water. Pour the water off. Notice the film around each marble and where the marbles are in contact. The water that ran off through the marbles is gravitational moisture, and the moisture collected around the marbles is capillary moisture.

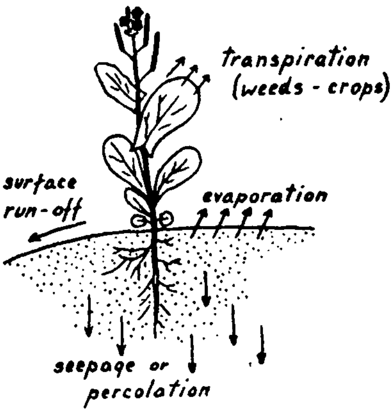
(3) Does the foregoing discussion of capillary moisture help you to explain why the clay retained more water than the sand in Exercise No. 4, page 6? Consider that, although they are smaller, the particles of clay have a greater total surface area than the sand particles.

Hygroscopic moisture is the water found in soils that have been thoroughly air-dried. Only intense heat will

separate it from the soil particles, so it is not difficult to see that it is not available to the plant.

The Loss of Soil Moisture and How to Prevent it.—Dry Farming.—A great deal of moisture is lost because it runs off over the surface of the ground. This loss may be partially prevented by keeping the soil loose by cultivation. A liberal supply of humus in the soil opens it up and allows the water to enter. It is often advisable to leave the stubble standing during the winter in order to trap snow and in this way collect moisture.

Much moisture is lost because it soaks down through a soil which is too loose. This may be partly checked by packing the soil, but a more effective method is to add humus or organic matter in the form of barnyard manure, etc. *The humus acts as a sponge and holds large quantities of moisture.*



The loss of moisture from the soil. (Draw.)

The greatest loss, however, is due to surface evaporation by sun and wind of the capillary or film moisture. To prevent this a *mulch* is produced by cultivating the soil to produce a thin layer, usually 3 or 4 inches deep, of loose dry soil particles on the surface of the wet soil. The ascending moisture will not pass through this blanket of soil.

Weeds, like all other plants, use an enormous amount of water. They serve no good purpose, and the water which they drink up is wasted. Fields should be kept free of weeds to prevent this loss.

When crops are sown too thickly, more plants are produced than the supply of moisture will maintain. The surplus plants waste valuable water. Crops should be sown at such a rate that each plant produced will be sure of a sufficient supply of moisture.

Plowing loosens the soil and very often leaves it lumpy so that it dries out quickly. To prevent this the soil should be harrowed immediately after it is plowed. What is the danger of the excessive use of the harrow?

Exercises.—(1) Secure 3 water-tight cans of equal weight. Fill each with equal weights of dry soil of the same kind, shaking the soil down well. Add an equal weight of water to each. Take some more soil, work it into a very fine state, and add a layer of ½ to 1 inch in depth to the wet soil in one can (this soil must be weighed and its weight taken into account when reweighing the can). Pack the surface of another can with the hand. Leave the other as it is. Expose all cans to the sun. Several days later reweigh, and notice from which can the most water has escaped. Weigh again in a week.

(2) Gather a sample of soil from the first 3 inches, second 3 inches, and third 3 inches of soil in a field, and a sample from the middle of a road which has been packed hard. Weigh each sample. Dry out the moisture. Weigh. Decide which contains the most moisture. Give reasons.

(3) Ask farmers about the danger of too fine a mulch.

In districts where the precipitation is less than 20 inches and the whole scheme of farming is directed to conserve moisture, the system is known as *dry farming.*

Kinds of Soil.—The kinds of soil depend chiefly upon the percentage of sand, silt, clay, and humus to be found in them.

Sandy soils will contain a large amount of sand, very little clay, and usually only a small supply of humus. In weight they will average about 110 pounds per cubic foot. They are coarse in texture, and the particles lie loosely together. Such soils do not hold water very well and are inclined to be too dry to raise good crops. As they often contain so little humus, their fertility is soon exhausted.

Clay soils contain very little sand or humus but are composed largely of clay. In actual weight they are lighter than the sandy soils, a cubic foot weighing on the average approximately 80 pounds. But clay soils are called heavy because they are sticky and difficult to work. Explain why this should be. They have great water-holding power, but in the spring they are frequently very

Courtesy of The Grain Growers' Guide, Ltd.

Cracks such as these in heavy land increase the loss of soil moisture by surface evaporation.

slow in becoming dry and warm enough to plant crops in. Like sandy soils, on account of the limited supply of humus which they contain it is difficult to maintain their fertility. After a heavy rain a clay soil bakes on top and forms a thick, hard crust.

Loam soils are about 50 per cent sand, 25 per cent clay, and 25 per cent humus. Such soils are usually productive and are considered to be the best for most kinds of crops. Loam soils are dark in color, moderately easy to work, and

if cultivated properly, will be found to hold just about the right amount of moisture for plant growth.

NOTE.—There are many variations of the above three classes of soils, such as *sandy loam, silt loam, clay loam,* etc.

Humus soils are composed chiefly of decayed or partially decayed vegetable matter. They are found in the bottom of swamps and marshes where vegetation has been heavy. Humus soils are usually very light and are not of much value for the production of crops.

Gumbo soils are a combination of clay and other materials. They are very sticky and exceedingly difficult to work. Gumbo is a poor soil for most crops, although, when properly managed, some gumbo soils produce fine yields of wheat.

Alkali soils are soils which contain an excessive amount of several soluble salts. (See page 29.)

Exercises.—(1) Which types of soils are actually heaviest? (See page 5.) Explain why certain types of soil are commonly called heavy.

(2) Prepare four samples of clay soil. To one add a supply of humus; to another a quantity of lime. Mix thoroughly. Now wet and pack into a ball all four samples. (*a*) Leave one pure clay sample and the two samples containing lime and humus at ordinary temperature until thoroughly dry. Compare as to hardness and friability. What treatment could you suggest for clay soils to prevent baking? (*b*) Freeze the second pure clay sample, then thaw and dry. Is it now friable or hard? When should clay soils be plowed to secure the most friable seed bed.

(3) Make a collection of the kinds of soil found in your district.

Project.—A very good classroom experiment to determine the best type of soil may be conducted as follows: Prepare several samples of soil, using sand, clay, and well-rotted manure or leaf mold. Samples should represent sandy, loam, and clay soils as described above. Place the soils in shallow window-boxes. Chalk-boxes are very satisfactory, but should be bound with wire to prevent them breaking apart when the wood becomes damp. Plant seeds of some quick-growing plant, as peas, beans, or wheat, in each box. Be sure that all conditions, such as kind of seeds used, depth planted, light and

heat exposure, amount of water supplied, etc., are maintained exactly the same for each box. Only by observing this precaution very strictly can any variation in the growth of the plants be attributed to the difference in the soil and not to some other cause. Watch the development of the plants for several months. Make written observations at regular intervals. At the end of the experiment summarize your observations and state conclusions.

Elements Required by Plants.—*Ten* elements are considered essential to plant life. Seven of these, *nitrogen, phosphorus, potassium, calcium, iron, sulphur*, and *magnesium*, are found in the soil itself. Water is the source of *hydrogen* and *oxygen*, and *carbon* is obtained from the air. The source of the elements and the form in which they are gathered by the plants is as follows:

Elements	Source	Form
hydrogen, oxygen	water	water
carbon	air	carbon dioxide
	soil	carbonates
nitrogen	air by legumes	free nitrogen
	soil by all other plants	soluble salts as potassium, calcium, iron, magnesium nitrate, phosphate, sulphate
phosphorus	soil	
potassium	soil	
calcium	soil	
iron	soil	
magnesium	soil	
sulphur	soil	

Fourteen elements are commonly present in plants, there being, besides those mentioned above as essential, sodium, silicon, chlorine, and manganese.

With the exception of nitrogen, phosphorus, and potassium, the supply of the plant foods found in the soil is sufficient to last a great many years. The three exceptions, because of the necessity of replacing them at

frequent intervals, become the controlling factors in soil fertility. *Plants drink their food from the earth or soil.* For this reason the plant foods in the soil are *available* to crops only when in a form that is soluble in water.

Nitrogen is found chiefly in the humus. It is essential for protein formation and growth, and is used in large quantities by all plants until flowering time. It increases the dark green color of the leaves, and the seeds develop better when an abundance of nitrogen is available.

Phosphorus is necessary for protein building. Seeds will not form without it.

Potassium performs a peculiar function in starch formation. No starch is formed if for any reason potassium is not available to the plant.

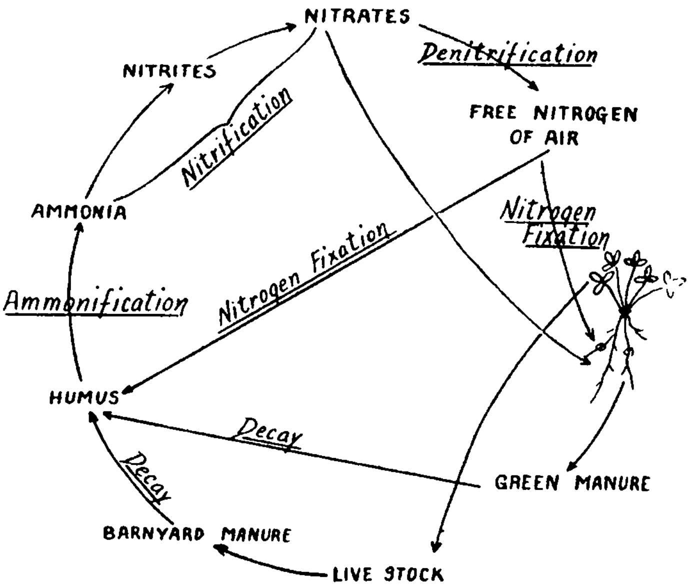
Calcium is valuable not only as a plant food, but also for the good effect which it produces in the soil. It assists in making nitrogen and other plant foods soluble. Its application to heavy, sticky soils makes them more loose and open. Do you recall an experiment that proves this statement? Sourness and acidity are corrected by additions to the soil of this element, usually in the form of lime.

Exercise.—What is the original source of the elements of plant food? How are they supplied to the soil by man? Do crop residues (stubble, roots, etc.) restore plant food to the soil?

Project.—Plant two geranium slips in separate boxes containing exactly the same kind of soil. Place the boxes where conditions of light, heat, etc., will be identical for each plant. Water both plants, as the soil becomes dry, using pure water for one plant and water with a pinch of sodium nitrate (Chili saltpetre) for the other. Make written observations at short intervals about the rate of growth, the color of the leaves, and any other variations which you see in the two plants. When the experiment is concluded, state clearly the influence of nitrogen upon the growth of plants. Make diagrams to show the results.

Bacteria in the Soil.—The soil is teeming with life. Near the surface of the soil are to be found millions of bacteria.

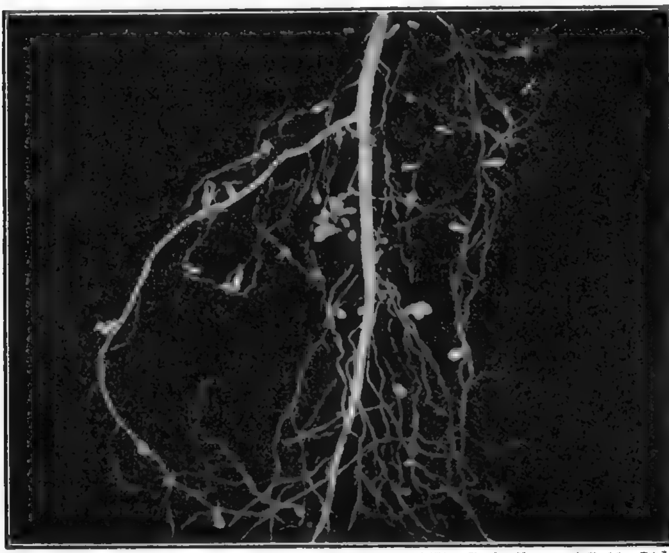
(See page 132.) Were it not for the good work performed by these microscopic plants, the productiveness of the soil could not be maintained. They are exceedingly important in changing plant food into soluble forms. Some of the bacteria help to decompose the bodies of dead plants and



The nitrogen cycle, that is, the movements of nitrogen between soil, plant, animal, and air. (Draw and explain.)

animals and thus increase the organic content of the soil. But harmful kinds of bacteria are also present. Fortunately, when the soil is in the best condition, those which are not useful are held in check. The desirable kinds require warmth, moisture, air, and food (humus). When the soil is cold, damp, and without air, the beneficial bacteria cease to function, and destructive forms become active.

Nitrification means the breaking up of the insoluble nitrogenous compounds of the humus to form soluble forms of nitrogen or nitrates. Several useful bacteria attack the humus in the soil. Decomposition of the humus follows, and the nitrogen in it is combined with hydrogen to form ammonia. The ammonia is then changed to nitric acid,



Courtesy of The Grain Growers' Guide, Ltd.

Nodules on the roots of alfalfa.

which unites with a mineral, usually calcium, to form a nitrate. The nitrate form of nitrogen is the one available to plants, as it is readily soluble in water. The bacteria which bring about these changes are collectively called *nitrifying bacteria* or *nitrobacteria*.

Denitrification.—There are in the soil forms of *denitrifying bacteria* which change the nitrates back into insoluble forms or into free nitrogen that escapes into the air. These are

the harmful bacteria mentioned before and are not active when the soil is in good tilth.

Nitrogen fixation.—The free nitrogen of the air cannot be used by most plants. However, certain bacteria, found only in the nodules on the roots of members of the legume family, are able to gather the nitrogen from the air and change it into a form in which it becomes available. This process is known as nitrogen fixation. Other bacteria, in no way connected with the legumes, have been found to be able to fix the nitrogen of the air, but these are not considered as important as the bacteria on the roots of alfalfa, clover, and related plants. (See notes on alfalfa and sweet clover, pages 79 to 85.)

CHAPTER II

SOIL PROBLEMS

The Maintenance of Soil Fertility.—*A fertile soil* is one capable of producing crops. The fertility of a soil depends largely upon the supply of plant food elements in it, but its power to hold moisture and the cultivation received also influence its ability to produce crops.

The Loss of Soil Fertility.—Every crop grown on a piece of land leaves the soil poorer by the amount of plant food which it has gathered. The loss of soil fertility due to cropping is, of course, unavoidable, but by correct methods much can be accomplished to reduce the waste and dissipation of the substance of the soil by weeds, drifting soil, excessive cultivation, denitrifying bacteria, erosion (washing of the soil by running water), and weathering.

PLANT FOOD ELEMENTS REQUIRED BY HARVESTED CROPS*

(Pounds per acre per year)

Crops	Yield per acre	Nitrogen	Phosphorus	Potassium
Alfalfa, hay	5 tons	238.0	23.6	185.0
Barley, grain	40 bu.	35.3	7.1	11.8
Barley, straw	1 ton	11.2	1.6	19.9
Clover, hay	2 tons	82.0	6.8	54.0
Corn, for ensilage	12 tons	81.6	16.7	87.5
Oats, grain	50 bu.	31.7	5.6	7.4
Oats, straw	1¼ tons	14.5	2.4	31.1
Potatoes, tubers	200 bu.	42.0	6.3	53.0
Rye, grain	25 bu.	26.5	4.5	6.6
Rye, straw	1¼ tons	12.0	3.0	16.4
Wheat, grain	30 bu.	35.6	6.8	7.9
Wheat, straw	1.6 tons	16.0	1.8	19.6

*From *Productive Soils* by W. W. Weir, J. B. Lippincott Company.

Unless steps are taken to restore the available supply of essential elements, the soil will become impoverished. A good farmer will feed his soil as he feeds his live stock. The methods employed by farmers and gardeners to restore and maintain soil fertility are *commercial fertilizers, barnyard manure, green manures, crop rotations including legumes and grasses, summerfallowing or substitutes,* etc. These are discussed on the following pages.

Commercial Fertilizers.—When the elements in the soil have become depleted, they may be restored by the careful use of specially prepared fertilizers.

Nitrogen is the plant food most commonly exhausted and most expensive to restore. *Sodium nitrate* (*Chili saltpetre*) may be used, and supplies nitrogen in a very soluble form. *Ammonium sulphate* is another valuable source, but in this salt the nitrogen is not so readily available. Bi-products of the abattoirs, such as *dried blood* and *tankage,* and *ground fish,* are rich in nitrogen and phosphoric acid. *Calcium cyanamide,* produced by passing nitrogen over calcium carbide heated to a high temperature, is a rich nitrogenous fertilizer but should be put on the soil at least a week before the crop is planted, as it is somewhat toxic (poisonous).

Nitrogen is frequently supplied in special quantities to crops that produce a strong growth of stem and leaf, such as lettuce, cabbage, spinach, melons, and legumes. Active growth in young plants is often stimulated by the use of a nitrogenous fertilizer, such as sodium nitrate.

To supply *phosphorus, bones* are used extensively. These are usually ground or steamed to make the phosphorus more available. Certain *rocks* contain moderate amounts of phosphorus, and, when finely ground, often form the basis of phosphoric fertilizers. They are sometimes treated with sulphuric acid to produce *acid-phosphate,* in which the

phosphorus is quite soluble. *Basic slag*, a bi-product of the manufacture of steel, is rich in phosphorus and lime and makes a splendid fertilizer.

Phosphoric fertilizers are employed chiefly for crops of which the seed or fruit is used.

Most of the *potassium* fertilizers formerly came from the Stassfurt mines in Germany. Recently, however, large deposits of *potassium salts* have been located in parts of America. These are now being mined and used for fertilizers. A rich source of potash is *wood ashes*, which are high in potassium in the form of potassium carbonate.

Potassium fertilizers are used for root or tuber crops, such as turnips, beets, or potatoes.

Calcium is applied to the soil by the use of *slaked lime* or finely ground *limestone*.

Commercial fertilizers alone will not maintain the fertility of the soil. They do not restore any organic matter, without which the soil will not produce crops. Consider this statement very carefully. Define "commercial fertilizers".

NOTE.—For suggestions on preparing fertilizers, send for the bulletin, *Fertilizers for Flowering Plants, Vegetables, Small Fruits, and Lawns.* Ex. Cir. No. 104. Publications Branch, Ottawa.

Barnyard Manure.—Barnyard manure is useful to restore phosphorus, potassium, and especially nitrogen to the soil. It also returns humus or organic matter, which improves the water-holding power of the soil, binds the soil particles together, encourages the activity of beneficial bacteria, and helps to ventilate the soil. The amount of plant food in manure will vary according to the amount of straw present, but it has been estimated that *one ton of manure will contain approximately 10 pounds of nitrogen, 8 pounds of potassium, and 3 pounds of phosphorus.* Manure must be handled carefully to secure full value from it. It should never be left where it can be washed or leeched by

rain, as this reduces its value as much as 50 per cent. The most economical practice is to get the manure on the land as soon as possible, providing there are no injurious weed seeds present. Rotting destroys the weed seeds, but results in a large loss of plant food.

Manure is the most efficient of all fertilizers. All crops are improved by the annual application of about 2 tons per acre to the soil. There is little danger of using too much with such crops as celery and rhubarb. Spring applications to land in which potatoes are to be grown should be avoided, as this practice increases scab disease on the tubers.

Exercises.—(1) How many tons of manure are required per acre to restore the elements of plant food removed from the soil by a 200-bushel crop of potatoes? (See table on page 20.)

(2) Calculate the tons of manure which must be applied to an acre to restore the nitrogen and potassium removed by a 45-bushel crop of oats.

(3) See problem on manuring on page 264.

Green Manuring.—A valuable method of increasing the organic content of the soil is to sow sweet clover or other leafy quick-growing crop and, when a good growth has been made, to plow it under as green manure. By doing this the fibre manufactured by the crop is put into the soil.

Summerfallow.—In this practice the land is not cropped but remains idle for a year in order that the soil may be thoroughly cultivated at intervals during the season.

The advantages of summerfallowing briefly are: All the rain that falls during the year is caught and, by cultivation after each shower, is held in the soil and stored up for the crops of the following seasons. Weeds are destroyed. Stubble and other vegetable material is decomposed. Insoluble plant food is broken up and made available to the crops. The land is prepared for early planting the following spring. Plant diseases and insect pests are checked.

But summerfallowing is practised much less than formerly in many parts of the country because, when not well managed, it may seriously damage the soil. The excessive cultivation destroys the fibre in the soil and frequently pulverizes it to such an extent that it blows badly. There is danger of making too much plant food soluble so that it is washed away, thus reducing the fertility of the soil. The crop following the summerfallow often grows too rank and lodges (falls down), or is so late in maturing that it is exposed to the danger of frost or such plant diseases as rust. No crop is produced while the land is being summerfallowed, and the expenses of cultivation are high.

The disadvantages may be overcome by the use of intertilled crops, such as corn, sunflowers, etc. Grain crops may be planted in triple rows, that is, three rows of grain then a space which may be cultivated. The advantages of inter-tilled crops as substitutes for summerfallow are that cultivation may be carried on between the rows, weeds destroyed, moisture conserved, and plant food made available, but the land, being covered, does not blow, and a crop is produced. Shallower or later cultivation of the fallow will render less plant food soluble. The summerfallow could be employed less frequently. (See page 27.) The fallow might be pastured for a large part of the time. Sheep will keep the weeds down, and there will be less cultivation.

Crop Rotations.—Mixed Farming.—If one crop is grown continuously on the same land, the plant food will soon become exhausted, and the crop will no longer do well. But if different crops are grown *in succession*, some will restore the elements which others remove. Grass crops, for example, because of their dense root system, will replace the humus destroyed by grain crops, and legumes will replace nitrogen. Weeds, insects, and plant diseases are checked, if not wholly controlled, by a succession of different

crops. The loss of the entire crop is prevented because it is not likely that, if more than one kind of crop is grown, all will be a total failure the same season. Not all crops are planted and harvested at the same time, and with a crop rotation it will be possible to arrange the work of the farm more evenly throughout the entire year.

A good rotation must include: a *cash crop*, an *improvement crop*, a *cleaning crop* (to destroy weeds), and a *utility crop* (to feed live stock). The main crop should be a cash crop, that is, one that will give a cash return to the farmer. Why? The cash crop is exhaustive and should be followed by such crops as legumes, grasses, or inter-tillage crops, that will improve and clean the soil. Deep-rooted crops should succeed shallow-rooted crops. To make the most profitable use of grass or legumes, where they are grown to any extent, live stock must form a permanent part of the farm system.

The system of growing other crops along with wheat and keeping live stock, instead of the practice of exclusive grain-growing, is called *mixed farming*. Continuous wheat-growing has robbed the soil in Western Canada of much of its fertility, and farmers are beginning to realize that mixed farming is the only method by which the soil will not in time become totally impoverished. Mixed farming means "Wheat for sale; oats and other feed crops for live stock; poultry, hogs, and sheep to utilize waste products and coarse grains."

The following is *an example of a crop rotation* suitable for prairie conditions. The farm is divided into six fields of equal size. A different crop is grown on each piece of land, and every year each crop is moved up one field. Let us follow this rotation for six years in one field and see how it works out. The first year *wheat* is sown. This is an exhaustive cash crop and is followed by a *grass* or *legume* to improve

the soil. The third year live stock are *pastured* on the grass until midsummer, and the land is plowed up and prepared for another *wheat* crop the fourth year. The fifth year a utility crop, such as *oats* or *barley*, is produced. The sixth year the land is *summerfallowed.* As much of the summerfallow as possible should be planted to corn, potatoes, and root crops. Give reasons. This rotation has been found to be very effective, especially in checking soil-drifting. (Manitoba Soil Survey Report.)

Exercises.—(1) In the above rotation how many fields each year are sown to wheat, to grass or legumes, to oats or barley, or are summerfallowed?

(2) Explain what effect each crop in the above rotation will have upon the soil.

(3) Would the fertility of the soil be reduced or not, after this rotation had been in use for 18 or 20 years? Give reasons.

(4) Draw a rectangle about 4 by 6 inches in size. Divide it into 6 parts to represent the fields of the above rotation. In each field neatly print the names of the 6 crops, one below the other. Place the name of the crop being grown in the current year at the top of the list in each field. See plan on page 32.

(5) How must the fields on a farm where crop rotation is practised compare in size?

(6) Would a series of crops such as wheat, oats, barely, and rye be considered a good crop rotation? Why?

(7) Calculate the quantity of the elements removed by different yields of the various farm crops.

(8) Approximately $\frac{2}{3}$ of the nitrogen in an alfalfa plant is in the top and $\frac{1}{3}$ in the roots and stubble.* How much nitrogen will there be (*a*) in the top and (*b*) in the roots and stubble of a crop of alfalfa yielding 2 tons of hay?

(9) About $\frac{2}{3}$ of the nitrogen which legumes require is taken from the air.* Is the nitrogen in the soil increased or not by a 2-ton crop of alfalfa (*a*) if the hay is removed and sold, (*b*) if the crop is plowed under as green manure, (*c*) if the crop is cut and fed to live stock and the manure spread on the soil? Note very carefully the facts brought out in Exercises Nos. 8 and 9.

*A. H. Joel, Professor of Soils, University of Saskatchewan.

Soil-drifting.—In many parts of the three Prairie Provinces soil-drifting has seriously damaged and often totally destroyed the crops on thousands of acres of land. The drifting particles of soil cut down the tender crops. Germinating seed is buried so deeply that it never reaches the surface. The roots of the young plants are left uncovered and exposed to the killing influence of wind and sun. Weed seeds are blown from one field to another. The soil itself is injured by the removal of the top and often the most productive layer. Roadways are blocked, ditches are filled, and fences become piled with the drifting soil.

The causes of this serious situation are: Very light rainfall maintains the soil in such a dry condition that it is readily picked up by the high winds so frequent in these areas. Bad farming practices are also responsible to a large degree. Too frequent or unsuitable cultivation reduces the land to a fine condition very easily blown. Continuous wheat-growing robs the soil of its fibre so that nothing remains to bind the soil particles together.

The remedy for soil-drifting is one of the greatest problems facing agriculturists to-day. Better systems of farming must replace present practices. To cultivate the land, implements must be used that will leave the soil lumpy or in ridges. It is now a fairly common practice, in some districts, to summerfallow without plowing, simply using the duck-foot cultivator throughout the summer, cultivating a little deeper each time that the field is gone over. Inter-tilled crops, such as corn, must replace bare fallows to a larger extent. A place must be made in crop rotations for more grass. Fall rye, which covers the soil in the fall and spring when high winds are most prevalent, is a useful preventative. A light seeding of oats (selected because of their cheapness), sown about August 1st on summerfallow, will hold the soil for the remainder of the season. More live

stock and more manure will keep the land in better condition. The prairies must be replanted with trees to reduce the velocity of the wind.

Exercise.—Some of these remedies can only temporarily check the tendency of the soil to drift. They do nothing to remove the real causes. Explain which of the remedies will do most to effect a

Courtesy of The Grain Growers' Guide, Ltd.

Fall or winter rye lessens soil-drifting. On the left a field of oats was completely destroyed by drifting. The rye was unhurt, except for 10 or 20 feet along the edge where the soil from the oat field blew into it.

permanent cure and give reasons for your opinion. Name three ways of restoring fibre to the soil.

Acid or Sour Soils. — Acid or sour soils are caused by a lack of lime. Low-lying, wet soils frequently become acid. This condition of the soil is unfavorable to the growth of many plants, and hinders both the nitrification and nitrogen fixation bacteria. Sometimes acidity in the soil may be corrected by drainage and aeration. The addition of some form of lime, which unites with the acid to form another substance, is always effective. (See test for acidity on page 3.)

Alkali Soils.—These are soils containing such large quantities of soluble salts that plants cannot grow. They are most common in areas of light rainfall or poor drainage. These conditions allow the salts to accumulate in the soil instead of washing them away. The salts are carried upward by the capillary rise of soil water, and deposited on the surface as the water evaporates.

Two kinds of alkali are found. *White alkali* is a mixture of sodium sulphate (Glauber's salts), magnesium sulphate (Epsom salts), sodium chloride (common salt), and a number of other salts. When sodium carbonate (washing soda) is present in the mixture, it dissolves the humus in the soil, giving a dark appearance to the salts, which are then called *black alkali.*

Alkali makes the soil solutions so strong that plants cannot use them. (See experiment on osmosis, page 47.) The structure of the soil is broken down and the soil reduced to a very fine, powdery condition. Black alkali destroys humus and even attacks the roots of plants. Some of the salts sometimes found in alkali spots are toxic or poisonous to plant growth.

To correct the alkaline condition of the soil it is first necessary to change the black alkali, if present, into white. This is a chemical change—the sodium carbonate is changed into a less harmful white alkali salt. It is accomplished by using calcium sulphate (gypsum or land plaster) at the rate of one ton per acre. The land must then be drained, if possible, to carry the alkali away. From 10 to 15 tons of strawy manure are next plowed deeply into the soil. What effect will the manure have on the soil? Thorough cultivation must be carried on during the remainder of the season to prevent the capillary moisture from depositing more salts on the surface. Irrigation will assist in washing the soil free of alkali.

The best crops to grow first on reclaimed alkali land are sugar beets or mangels. These were originally salt marsh plants and have become adapted to alkaline conditions. If the alkali is not too strong, oats or barley may be grown.

Exercises.—(1) Mix a little soda or common salt with some fine soil. Tie cheese-cloth over the bottom of a lamp chimney or wide glass cylinder and fill with the mixture. Place in a vessel of water as described in capillary moisture experiment on page 10. Keep a good supply of water in the lower vessel. After a week allow the surface of the soil to become dry. Notice the salt that has been deposited there by the water. Using the results of this experiment explain how alkali salts accumulate at the surface of the soil.

(2) Explain the direction in which osmosis would take place if the strong solutions were outside of the plant.

(3) If there are alkali spots in your district, arrange to visit one or more. Notice if plants are growing there. Are the spots in high or low locations? Would it be possible to drain the spots? Examine the soil. Collect samples and apply test on page 3.

(4) In districts where there are alkali spots it is found that in wet years there is less alkali in the soil than in dry years. Explain.

Irrigation.—In Southern Alberta and parts of South-western Saskatchewan the rainfall is so light that, although the soil is good, profitable crops cannot be produced. To use the land in these districts for agricultural purposes moisture must be supplied artificially by irrigation. Water is brought into the dry areas by means of huge ditches or canals. To control the flow of the water, locks or gates are built at intervals along the ditches. From the main ditches smaller laterals carry the water to all parts of the districts.

Several methods may be used by the farmer to direct the water from the ditches over his fields. One way, known as *free flooding*, consists of turning the water into a field at a high part and allowing it to flood the soil according to the natural slope of the land. When this method is used, much water is wasted, and it is difficult to get the land flooded evenly. A more satisfactory practice is the *border system.*

The field is divided into strips by ridges of soil two to three feet wide and four to six inches high. The ridges enclose the strips so that they may be flooded one at a time. The water is turned into the highest strip and allowed to flood it thoroughly. An opening is then made in the ridge, and the water is directed into the next strip. This is the method recommended for permanent use. The ridges are low and flat enough to be seeded to crop. A third system, known

Courtesy of The Grain Growers' Guide, Ltd.

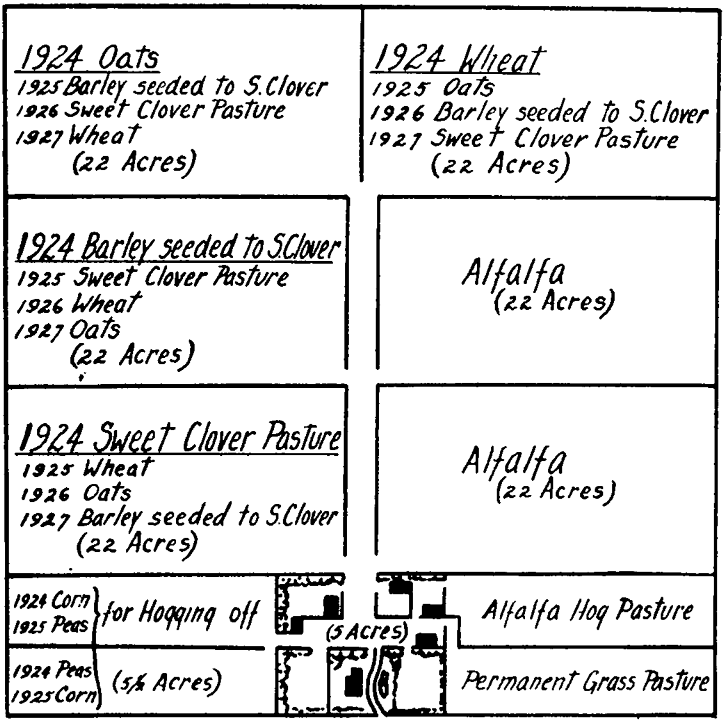
The furrow system of irrigation.

as the *furrow method*, carries the water over the fields by furrows. This method is used most commonly for intertilled crops. The furrows are placed between the rows. The water runs down the furrows and soaks into the soil, which should be thoroughly cultivated as soon as it is dry enough. Why? In any system of irrigation the land must be as level as possible.

Fall irrigation gives the best results. During the summer grain crops should be irrigated only if necessary. Alfalfa requires irrigating in the fall and after each cutting. For

grass crops a continuous supply of water is necessary for greatest yields, as grasses use a very large quantity of water.

The soil must be thoroughly moistened to a depth of about a foot each time it is irrigated. Water is required



Crop rotation for 160 acres on the Lethbridge Northern Irrigation System, suggested by District Agriculturist M. L. Freng. (Draw.)

when soil from this depth, squeezed in the hand, falls apart —if it remains in a lump it contains sufficient moisture. Care must be taken not to over-irrigate, as this is liable to produce a water-logged soil by causing a rise in the water-

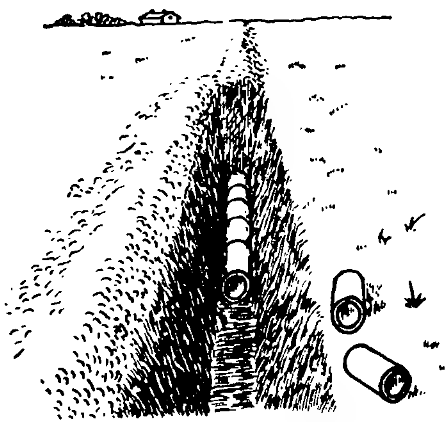
table (page 9). Over-irrigation may also develop an alkaline condition of the soil as described in the previous section.

Irrigation means intensive mixed farming. Every part of the farm must be irrigated and used. The crop rotation must be planned to use the water at all times, and should include legumes such as alfalfa or sweet clover, inter-tilled crops (for which purpose sugar beets are recommended), and some grain crops. Live stock are essential in any irrigation farm system.

Exercises.—(1) Arrange to visit an irrigated farm and have the farmer explain his method of irrigation.

(2) What value will the crops recommended above have as cash crops or soil-improvement crops?

(3) For further study send to the Department of Agriculture, Edmonton, for the bulletin on *Practical Irrigation for Alberta*; and to the Department of the Interior, Ottawa, for Bulletin No. 6, *Irrigation Practices and Water Requirements for Crops in Alberta*, and others of the Irrigation Series.


A tile system of drains under construction: the open ditch in the foreground, then the tile laid in place, and in the background the ditch filled in.

Drainage.—Frequently the value of heavy, sticky soils or of soils in swampy, low-lying locations is reduced or destroyed by the presence of too much gravitational water (see page 9). If such soils are to be used for crop production, the excess moisture must be removed. This may be done by means of *open ditches* or by *under-drains* or *tile systems*. The under-drains are built by

burying short lengths of tile or cement pipes, end to end, at a depth of from 2 to 3½ feet below the surface of the ground. Water soaks down through the soil and into the tiles through the joints. For efficient drainage the tiles should have a fall of 1 or 2 feet in every 100 feet. The open drains are more cheaply constructed and give better results when a large volume of water must be removed; but they are continually becoming clogged with rubbish, they cause the erosion of the soil, they use up land that could otherwise produce crops, and their banks are favorable growing places for noxious weeds. The under-drains are more satisfactory for permanent use. By efficient drainage many hundreds of acres of useless swamp land have been converted into profitable farm areas.

Exercises.—(1) What are the injurious effects upon the soil and plant growth of excessive gravitational moisture?

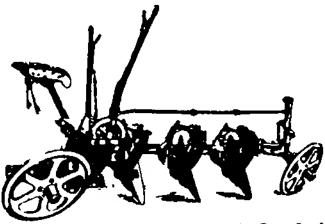
(2) State the advantages of the tile system of drains.

CHAPTER III

FARM MACHINERY—USES AND CARE

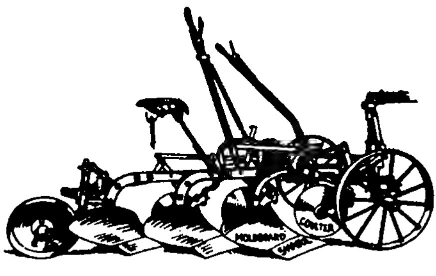
The invention of machinery has done a great deal to reduce the cost and labor of farming. It is, however, necessary for the farmer to study very carefully the various types of machines now available for each operation on the farm, in order to know which is best suited to his particular requirements.

Tillage.—Tillage means the cultivation of the soil: to prepare a seed bed for crops, conserve moisture, loosen and pulverize the soil, bury stubble, and destroy weeds. State three important disadvantages of excessive tillage.



Courtesy of The Massey-Harris Co., Ltd.
A disc plow.

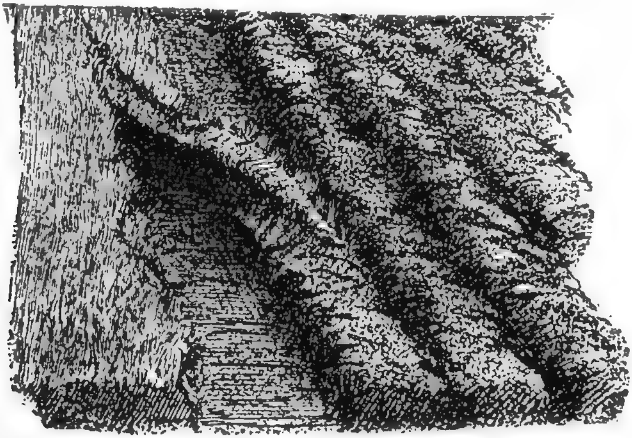
Tillage Implements.—The *plow* turns the furrow upside down, pulverizes and aerates the soil, buries stubble and weeds, and, if the furrow slice is deep enough, brings new soil to the surface. Plowing is spading on a large scale.



Courtesy of the Massey-Harris Co., Ltd.
A three-bottom moldboard plow.

There are *two types of plows*—the *moldboard* and the *disc*. The moldboard plow is more satisfactory in most types of soil. It pulverizes the soil and cuts weeds better than the disc plow, but where the soil is heavy and sticky,

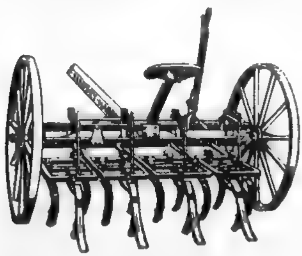
and the moldboard plow will not clean, the disc plow must be used. How are the discs of the latter plow kept clean?



Courtesy of The Grain Growers' Guide, Ltd.

Plowing, showing how the moldboard plow turns the furrow slice upside down.

The *cultivator* is used for working the surface of the soil. The broad or duck-foot cultivator, or a rotary rod cultivator, is the best to destroy weeds. On summerfallow the cultivator leaves the soil in ridges and lumpy. In this condition the soil is in less danger of drifting. Cultivating is hoeing on a large scale.

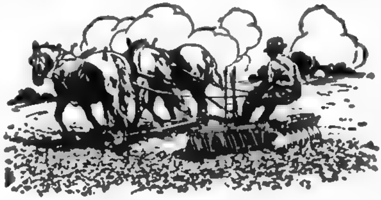


Courtesy of The Massey-Harris Co., Ltd.

A cultivator. This machine can be fitted with different kinds of points for different classes of work—narrow points for deep cultivation and heavy soils, wide points for shallow cultivation and weed cutting.

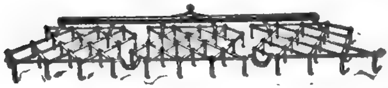
The *disc harrow* is also a surface cultivator. It is a useful implement to destroy weeds and conserve moisture. The disc is frequently used after the plow to cut up soddy land.

The *drag harrow* is employed to pulverize the surface of the soil to conserve moisture and destroy young weeds. A stroke of the harrow is often beneficial to growing crops, such as wheat, potatoes, corn, etc., when 5 or 6 inches above the ground. Harrowing is raking on a large scale. State the danger of harrowing the soil too much.

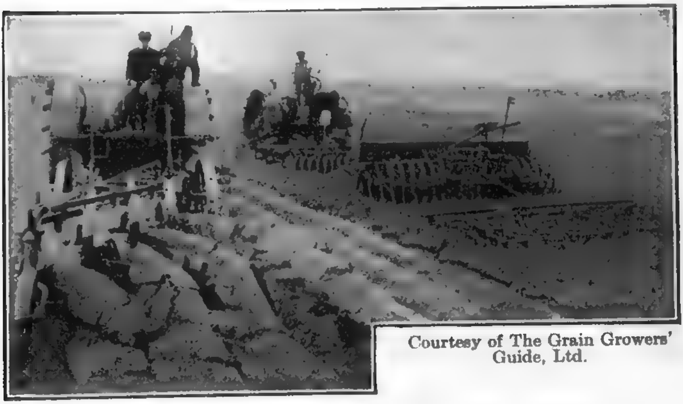


A disc harrow.*

Soil packers.—The *packer*, *roller*, and *drag* or *float* are used to press the soil around the seed and to pack and pulverize the soil to facilitate the movements of soil moisture. If the packer is used to excess, the soil becomes too fine. What is



A drag harrow.



Courtesy of The Grain Growers' Guide, Ltd.

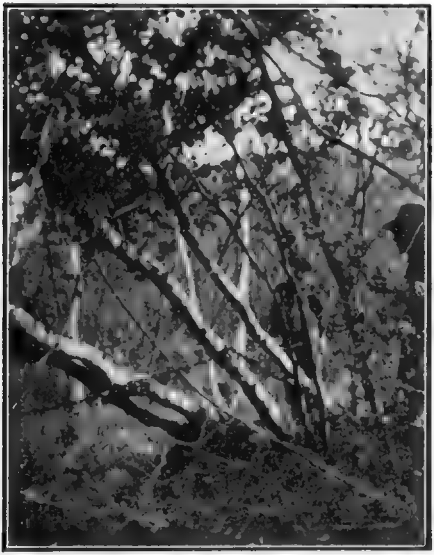
Breaking, discing, seeding, and harrowing. Flax is being sown.

the objection? There are two chief types of packers

*The illustrations in this chapter not otherwise acknowledged are reproduced by courtesy of The International Harvester Co., Ltd.

—the surface and the sub-surface. A drag is built of logs or planks and is useful to level uneven surfaces.

Breaking.—Breaking means the first cultivation of new land. Prairie should be plowed shallow early in the year. The furrow must be laid quite flat, and it is usually advisable to pack the land immediately after plowing. During the summer the soil must be well disced and harrowed to conserve moisture and destroy grass and weeds. When the soil has become well rotted, it is backset or plowed again, disced, and harrowed. In many districts the practice is to plow deeper at first without backsetting. Thorough cultivation subsequently is necessary to ensure success by this method. Frequently, although not always with good results, a crop such as flax or wheat is sown on breaking.



Courtesy of The Grain Growers' Guide, Ltd.

Pulling trees down with a chain and tractor.

When scrub land is being broken, it is plowed deep early in the season, and packed, disced, and harrowed during the remainder of the summer. It is not plowed the second time until the following year or later, in order to give the growth plowed under time to rot. Large trees must be cut down by hand or with a brush cutter, burnt off, or pulled down by a chain and a tractor or horses. Smaller trees and

bushes may be drawn under the furrow and buried by means of a chain attached to the plow.

The Cultivation of Stubble Land.—There are many methods employed to prepare stubble land for another crop. The most common practice, however, is to plow the soil and follow this operation with some form of surface cultivation. Give reasons for the second operation and name the implements used. (See page 76.)

In humid regions, or in wet autumns, *fall plowing* is more satisfactory. Weeds are more effectively destroyed, but the soil is inclined to dry out. Better results are obtained if fall plowing is done early and to a good depth unless shallow cultivation is required for some special purpose.

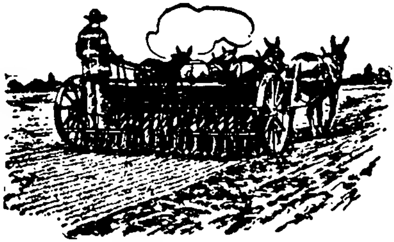
In dry districts, or following dry summers, *spring plowing* has several advantages. If the stubble is allowed to remain during the winter, it catches the snow. When the land is plowed in the spring and the crop sown shortly afterwards, there is less time for the soil to become dried out.

"*Stubbling in*" is the practice of sowing the crops on stubble land with very little or no cultivation. When an abundant supply of moisture is available, good returns are frequently obtained, but "stubbling in" is not advisable unless the land is very clean and in a good state of tilth. This method of sowing crops also encourages the development of such insects as the wheat-stem saw-fly and is condemned on this account.

Seeding Machinery.—Planting seed by a drill or seeder has many advantages over the broadcasting method. All types of seeders open a small furrow, drop in the seed, and cover it with soil. The drills (rows) are usually 6 inches apart. The depth of the furrow may be regulated and the seed sown at any desired distance below the surface of the ground. What advantage is there in placing the

seed fairly deep into the scil? The amount of seed sown is controlled by opening or closing the openings through which the seed drops.

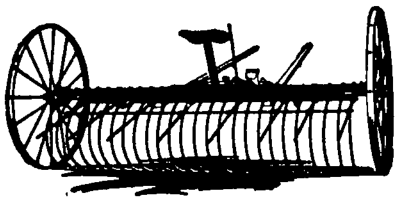
Types of drills.—The *shoe drill* is the cheapest and probably the best in wet land. *Double* or *single disc drills* are more expensive but get over trashy land better. The *press drill* and the *hoe drill* are useful in special conditions but are less commonly used. *Grass seeding attachments* are found on many drills, and there are also special *grass seeders*. Grass, however, may be sown by an ordinary grain drill.



A drill or seeder.

A mower.

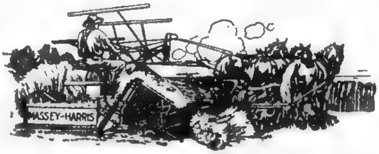
Harvesting Machinery.—The *mower* cuts grasses or grains not to be tied into bundles, and leaves the crop lying on the ground as cut. It is necessary to follow the mower with the *rake*, which gathers the crop into windrows or piles to be cured. Name the crops harvested in this way.



A rake.

The binder.—The grain is cut, thrown upon the table canvas and carried to the elevator. The elevator canvases raise it to the decks, where it is packed into a sheaf. The needle wraps a length of twine around the bundle, and the ends of the twine are tied by

the knotter. The twine is cut by the knife, and the sheaf discharged on to the carrier, where it remains until the operator desires to drop it to the ground. Care must be taken as the sheaf is being formed to have all the heads of the grain at the top, and the butt end of the bundle as square and flat as possible. Give reasons for these precautions.



Courtesy of The Massey-Harris Co., Ltd

A grain binder.

Where varieties of grain that do not shatter readily are grown, a *header* may be used to harvest the crop. This machine cuts the heads of the grain only, leaving a very tall stubble. There are also *combination harvesting machines*, which cut and thresh the grain in one operation, but these are not common in Western Canada.

The *corn harvester* cuts and ties corn into sheaves. The packing and tying mechanism is very similar to the packers and knotter of the grain binder, but is more stoutly built.

Courtesy of The Grain Growers' Guide, Ltd.

A binder with a stooking attachment. Watch the newspapers, etc., for announcements about new harvesting machinery.

The *sheaf loader* gathers the sheaves from the stook and elevates them into the bundle-wagon. There are also combination loaders, which load up the sheaves and carry them to the threshing machine.

Threshing Machines.—The sheaves should be thrown head first into the thresher. They are carried by the feeder canvas to the knives, which cut the twine. From there the grain passes between the teeth of the cylinder

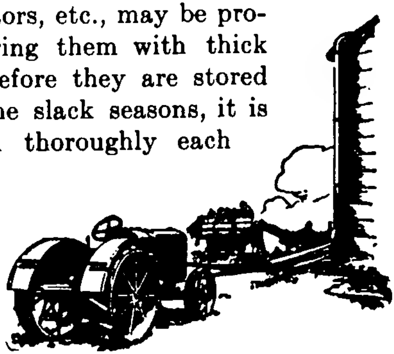
Courtesy of The Acme Manufacturing Company.

A sheaf loader in operation. The loader is picking up the sheaves from the windrow and elevating them into the wagon at the side of the loader.

and those of the concaves. The cylinder revolves at a high rate of speed, and, as the concaves hold the grain back for an instant, the cylinder teeth strip the kernels from the straw. The grain is then separated from the chaff and straw by a fan and a series of sieves. Finally, the grain is elevated, weighed, and run into a wagon or bin, and the blower throws the straw on to the stack.

The Care of Farm Machinery.—On many farms binders, drills, and other implements are worn out in a few years, while on other places the same kind of machinery, doing very similar work, is maintained in good running order for a long period. All farm implements, when not in use, should be protected from the weather by a machine shed, which need not be expensive. If there is not an implement shed on the farm,parts of some of the machines, such as the knotter and reel of the binder, can be removed and

stored under cover. During operation machinery requires constant attention to keep the various parts tight and in place, and each bearing must be properly and frequently lubricated. Polished surfaces, such as the moldboards of plows, the teeth of cultivators, etc., may be protected from rust by covering them with thick lubricating oil or grease before they are stored for the winter. During the slack seasons, it is a good plan to overhaul thoroughly each machine and adjust or replace worn parts. Paint, especially on wooden parts, does much to add to the life of the implements of the farm.



Filling a silo. Notice the silage cutter and the pipe through which the cut-up material is blown to the top of the silo.

Exercises.—(1) Name the machines required to produce an acre of wheat.

(2) From farmers in your district find out how long a plow, binder, or other machine wears on the average farm.

(3) A binder costs $284. Verify this from home or an implement company. Calculate the average rate per cent of depreciation if it cuts 12 crops.

(4) Should a clay soil be plowed when wet? Give reasons. Which type of plow does the best work in a sticky clay soil? Why? Which type is used in your district?

(5) Ask the local implement dealer for leaflets describing farm machinery. Visit his show-room and discuss the machines with him.

CHAPTER IV

BOTANY OF THE FARM AND GARDEN

Plants play a very important part in our lives. In fact, all animal life is dependent, directly or indirectly, upon food materials produced by plants. Man has made many attempts to manufacture starch and other essential food compounds, but so far the secrets of these food-making processes remain hidden within the plants.

Exercise.—Write a paragraph explaining how animals, including man, are dependent upon the various forms of plant life. Man obtains food, clothing, medicine, fuel, and building materials from plants. Discuss each of these and others that suggest themselves to you, and name several plants used for each purpose.

The Roots of the Plant.—The student should already know that the roots gather food (water and mineral matter in solution) from the soil, and convey these materials to the stem. The root also anchors the plant, and some roots (biennials and perennials) store food for future use.

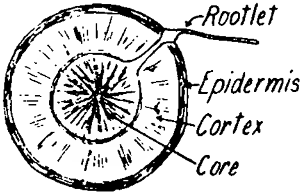
Kinds of Roots.—**Exercises.**—(1) Compare the root of a wheat plant with that of a carrot. Notice the number and comparative size of the branches or divisions of each root and the general direction in which they grow. Describe each root.

(2) Make labelled drawings of the roots of wheat, oats, and other grains, of carrots, beets, and other plants of the garden, and of dandelions and other weeds. Show clearly, in each case, the tap or fibrous nature of the root.

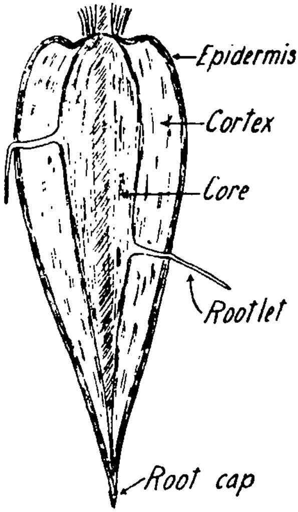
The wheat has a *fibrous* root and the carrot a *tap* root. Wheat is an annual plant, that is, it lives but one year. Its roots are *annual* roots. The carrot root lives for two years and is called a *biennial*. *Perennial* roots endure for many years. A perennial or biennial root may be either

tap or fibrous. Look for examples. The main part of a root is called the *primary* root, and the branches are *secondary* roots. The smaller parts are *rootlets.*

The Root System.—The root system includes all the roots of a plant. Its extent or size will depend upon the kind of plant, the nature of the soil, and the depth of the moisture. Roots have been known to go to great depths in search of water.



Project.—When a plant is pulled out of the soil, most of the roots are torn off. Carefully dig up a plant and gently wash the soil away. Do not try to accomplish this too hurriedly. Even with great care many of the smaller roots will be lost. Divide the root among members of the class. Separate the parts and lay each piece end to end. Measure the length of each part and add the results together to get the total length of the root system.



A cross and a longitudinal section of a root (carrot). Look for the same parts in other roots. (Draw.)

The roots of a wheat plant, when stretched out in this way, have been found to measure 600 yards. The root system of a pumpkin plant measures 50 times as long or over 15 miles. Wheat, oats, corn, and other cereals may send their roots 4 feet or more into the soil.

The Structure and Function of the Parts of a Root.—

Exercises.—(1) Cut a carrot crosswise and lengthwise with a sharp knife. Observe in the centre a darker part. This is the *core* or *central cylinder*. Around the core is the *cortex*. Notice the thin skin

or *epidermis* covering and protecting the cortex. If the carrot has been carefully taken from the ground, the small branches will remain attached to it. These are the *rootlets.* Observe that they spring from the core. Notice that the core leads to the stem.

(2) Remove a piece of the cortex and taste it. What substance do you recognize? Pour iodine over the surface of a slice of carrot. A dark blue color indicates the presence of starch. Observe carefully which part of the carrot turned blue. Taste a piece of the core. The slightly bitter or watery taste is due to the presence of mineral solutions from the soil. Does the structure of the carrot indicate which parts brought these solutions from the soil to the core? Are starches and sugars raw or manufactured foods? Decide the same question about soil solutions.

(3) At the tip of the root there is a tough *root cap* that fits over the end like a thimble. Place some geranium, Tradescantia (Wandering Jew), or willow slips in water and notice the root caps on the roots that develop.

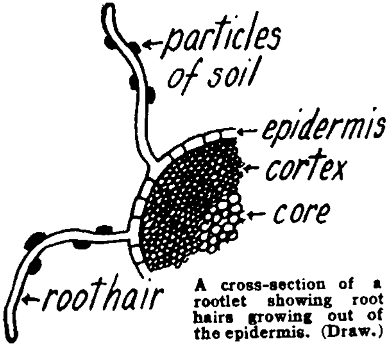
The parts that have been observed in the roots of the plants examined in the foregoing exercises will be found in all roots. Each part performs a special function in the work of the root. The rootlets and root hairs (see following section) gather the raw food from the soil and pass it along to the core, which in turn conveys it to the stem. The epidermis is the protecting cover that prevents the root from drying out. In some roots, such as the carrot, the cortex is a storehouse in which manufactured foods (starch, sugar, etc.) are stored for future use. The root cap protects the tender growing tip of the root.

The tip of a growing root. (Draw.)

Root Hairs.—Exercises.—(1) Place a few radish seeds loosely between sheets of moistened blotting paper. After three or four days examine carefully. Notice that the young roots are covered with minute, white, hair-like outgrowths. These are known as *root hairs.* Very carefully place a root under a magnifying glass and study the characteristics of the root hairs.

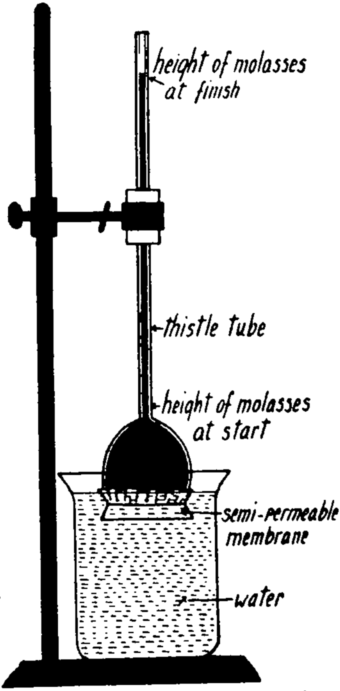
(2) Compare root hairs and rootlets as to size, structure, function, length of life, and the part of the root from which they grow.

The root hairs are extremely delicate, long tubes that grow out of the epidermis of the rootlets and the tips of the roots. As a root grows older, it becomes covered with a tough, water-proof bark, and the root hairs along its length die and are replaced by new ones near the growing tip of the root. *The root hairs are the chief food-gatherers of the root.* If the roots of trees or other plants are exposed to the sun, as during transplanting, the tiny root hairs are quickly killed, and the food-absorbing power of the plant is seriously injured.



A cross-section of a rootlet showing root hairs growing out of the epidermis. (Draw.)

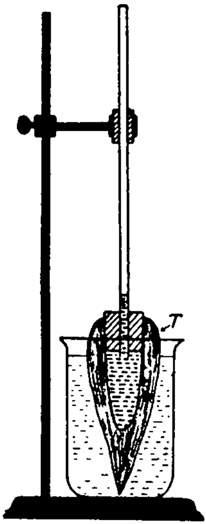
How Roots Absorb Solutions from the Soil.—**Exercise.**—Fill the bulb of a thistle-tube with molasses. (If the stem end of the tube is stopped by a cork or the finger and the molasses poured quickly into the bulb, the air trapped in the stem will hold the molasses in the bulb.) Over the mouth of the thistle-tube stretch and tie a porous membrane. (A piece of pig's bladder or cellophane, the thin transparent material now used extensively as an outside cover-



An experiment to illustrate osmosis. (Draw.)

ing of candy boxes, will do. Soften each in water before using.) Fill a beaker with water. Turn the thistle-tube mouth down and fasten it to a stand so that the membrane is well under the water in the beaker. After several hours or over-night make the following observations: the fall of the water in the beaker, the rise of the molasses in the thistle-tube, and the color of the water in the beaker. Explain. In what direction has the greatest exchange of solutions taken place?

Arrange the apparatus, placing water in the thistle-tube and molasses in the beaker, and compare the results in this case with your observations above.



A carrot osmometer. Bore a hole in a good-sized carrot and fill with molasses. Insert a glass tube into a one-holed rubber cork, and fit the cork into the hole in the carrot. Be sure to bind the carrot tightly to the cork at the point marked "T". Have a committee prepare this to supplement the experiment outlined in the text.

In each of the foregoing experiments you will notice that a large quantity of the water soaked through the membrane into the molasses. The process is known as *osmosis*, which may be defined as the diffusing or passing of solutions through a membrane.

Plants growing in ordinary soil live in conditions where the solutions of sap in the plant are stronger than the solutions of plant food in the soil. Therefore the direction in which the solutions move will be from the soil into the plant. The sap in the stem is forced some distance up into the stem by the incoming plant food. Other processes then take place to carry the food on up.

Exercise.—Alkali soils are those containing large amounts of soluble salts. These salts make the soil solutions very strong. Very few plants can grow in alkali spots. Explain fully.

Conditions Necessary for the Growth and Work of the Roots.—**Exercise.**—Obtain four vigorously growing plants in boxes or flower pots. Number them 1, 2, 3, and 4. Plant 1 is to be watered

regularly as the soil becomes dry and otherwise maintained under conditions that will encourage its growth. Place the pot containing Plant 2 in a vessel of water, completely submerging the roots. Allow Plant 3 to stand for a time with its roots in ice-cold water. Do not water Plant 4 at all. Make written observations at frequent intervals and, when complete, write a statement of your conclusions.

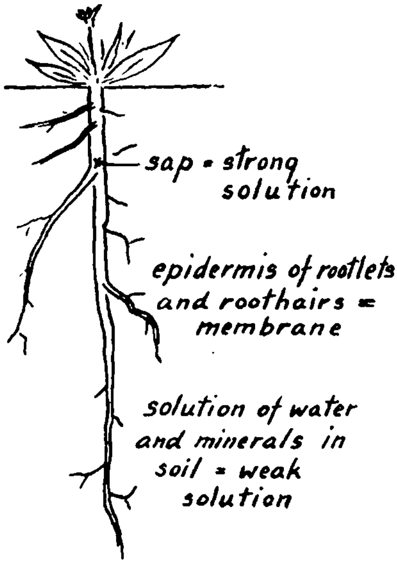


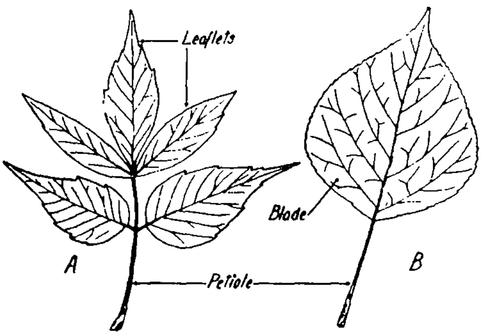
Diagram to show how roots absorb solutions from the soil. (Draw.)

Plants require water, but not too much. Plant food in the soil must be in solution before the roots are able to absorb it. Water-soaked soils do not contain sufficient air for the roots. Notice that, when water is allowed to remain in a low spot in the field, the plants become yellow and sickly in appearance. Plants should not be watered with ice-cold water. The roots require warmth. If they are chilled, the plant wilts.

The Leaves.—The leaves are factories in which the raw materials gathered by the plant are manufactured into starch, sugar, protein, and other food materials necessary for the growth of the plant.

Kinds of Leaves.—Leaves such as the poplar, elm, or geranium are *simple leaves.* When the leaf is divided into several parts or *leaflets*, it is called *compound.* Trees that shed their leaves in the fall are said to have *deciduous* leaves. The leaves of evergreens are *persistent.* The veins are the framework or skeleton of the leaf, and they carry food

materials from one part to another. In some leaves the veins are criss-crossed like the meshes of a net. Such a leaf is called *netted-veined.* Grasses and related plants have *parallel* or *straight-veined* leaves, because the veins run parallel to each other from end to end of the leaf. To see the veins, hold the leaf up against the light. The flat, broad part of the leaf is the *blade*, and the stem is the *petiole.* At the lower end of rose and some other compound leaves there are small parts called *stipules.*



A, a compound leaf. B, a simple leaf. Can you name these leaves? (Draw.)

Exercise. — Collect and examine leaves of the following plants: grasses, grains, trees such as poplar, elm, maple, ash, etc., clover, peas, beans, caragana, geranium, weeds, and others. Make labelled drawings of typical compound and simple leaves, parallel and netted-veined leaves, etc. Label the blade and petiole. Notice the shape of the end of the petiole and look in the end for the fibro-vascular bundles. (See page 56.) Compare the horseshoe-shaped end of the petiole with the scar left on the branch. Are the edges of the leaves examined smooth or toothed?

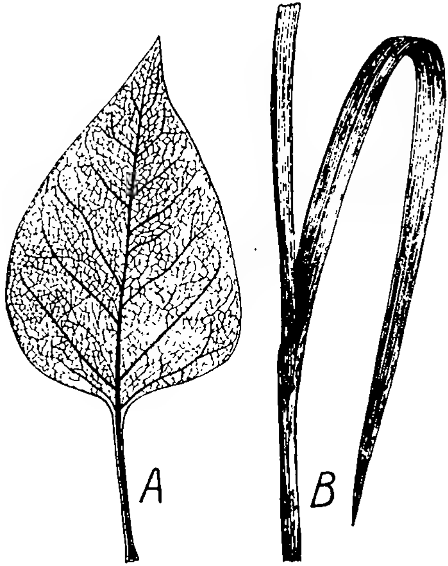
Chlorophyll or Leaf Green.—**Exercise.**—Prepare a beaker of boiling water. Dip a green geranium leaf into the water for a minute or two. Place the leaf in an evaporating dish and cover it with wood alcohol. Set the evaporating dish in the top of the beaker. Be very careful not to spill the alcohol over the flame below the boiling water. In 15 or 20 minutes observe the color of the leaf and the alcohol.

The green coloring matter dissolved from the leaf in the foregoing experiment is called *leaf green* or *chlorophyll.* It plays a most important part in the work of the leaves.

Exercise.—To demonstrate that sunlight is necessary to produce a healthy green color in the leaf, perform the following tests: (1) Place a plant in a dark cupboard, water it frequently, and notice the change in color. (2) Germinate some radish seeds, keeping them completely in darkness. After a few days observe the color of the seedlings. Then place them in the light and watch how quickly they become green. (3) Cover a small patch of the lawn with a board and observe then how the grass loses color. (4) Observe some potato tubers which have been sprouting in the dark.

Starch in Leaves.—**Exercises.**—(1) Place a few grains of starch in a test-tube. Fill with distilled water. Add a few drops of iodine. Notice the dark blue color produced.

(2) Set a plant away in a dark cupboard. After a day or more take a leaf from this plant and another from a plant that has been in full sunlight. Dissolve the chlorophyll particles from the leaves. Place the leaves on a piece of glass and apply the iodine test for starch.



The venation of leaves.
A, netted-veined. B, parallel-veined.

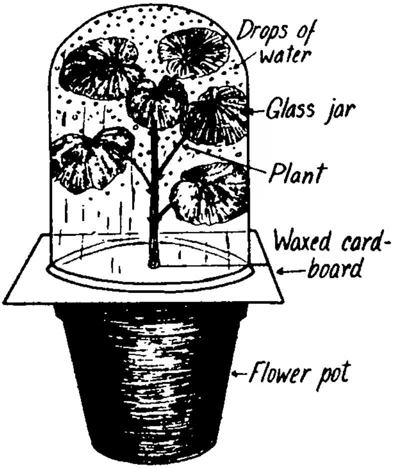
(3) Remove a leaf from a plant, such as a geranium or foliage plant, having leaves with white and green parts. Test for starch.

Light and chlorophyll are necessary for the manufacture of starch. The relation of these to the starch-making process will be discussed more fully later.

Respiration.—Plants, like animals, breathe. The plant cells require oxygen, and the carbon dioxide produced by the processes that take place in the cells is a waste product

and must be removed. The leaves are the chief breathing organs of the plant.

Transpiration.—The Importance of Water to the Plant.— **Exercise.**—(1) Using a small potted plant, cover the soil tightly with oiled paper to prevent the escape of any moisture. Invert a glass jar over the plant and place it in full sunlight for half a day or more. Observe that a mist collects on the inside of the jar. Later drops of water gather. Finally the drops are running down the sides of the jar. A large quantity of water has been given off by the leaves in a short time.



An experiment to illustrate transpiration. (Draw.)

(2) Place a drop of alcohol or gasoline on the back of your hand and observe the cooling effect as it evaporates.

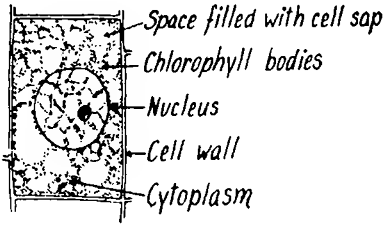
A very large quantity of water passes off from the leaves of plants. It has been estimated that from 200 to 500 pounds of water are required by the plant in order to produce one pound of dry matter. (See problem on page 8.) Water is the agent that dissolves the plant foods in the soil, thus changing them into a form available to the plant. 1
It dissolves and transports food material from one part of the plant to another. 2
It keeps the plant turgid and erect. 3
When the roots send up enough water to keep the cells of the leaves and stem pumped full, the cells are rigid; but if the roots fail to maintain the water pressure, the cells become dry and collapse, and the plant wilts. Water provides hydrogen and oxygen for making starch. 4
The transpiration of water from the leaves assists in keeping the plant cool. 5

Photosynthesis, the Manufacture of Carbohydrates.—The roots send up *water*, which is composed of hydrogen and oxygen. During the day the leaves absorb *carbon dioxide*, a compound of carbon and oxygen. The *chlorophyll* particles absorb *energy* (power to do work) from the *light*. This energy is used by the leaves to produce *carbohydrates* from the water and the carbon dioxide. (See page 191.) The process is called *photosynthesis*, which means to put together by means of light. *Sugar* is first produced, then *starch*. Some of the *oxygen* is left over and is given off as a waste product.

The Transportation of Carbohydrates.—Digestion.—Water is the solvent in which food materials are moved from one part of the plant to another. Starch is not soluble in water, but for transportation it is changed back into sugar by an *enzyme* in the leaf. The process of changing starch to sugar is called *digestion* and corresponds to digestion in the animal body. Sugar readily dissolves in water and is distributed to all parts of the plant.

The Uses of Carbohydrates.—Cellulose.—Protein.—Fats.—Protoplasm.—If the juice and pulpy part are squeezed from a plant, there are left the tough, woody cell walls. These are composed of a material called *cellulose*, which is composed largely of carbon. Carbohydrates have been used to produce the cellulose. Wood is composed chiefly of carbon. The leaves combine carbohydrates with *nitrogen*, sulphur, and a little phosphorus to produce a food compound called *protein* (see test, page 190). Some of the carbohydrates are also broken up and rebuilt into *fats* and *oils*. On the process of photosynthesis depends the world's supply of food. More carbohydrates and other materials manufactured in the leaves are used to produce *protoplasm*, which is the living material of all active cells. It is a clear, semi-fluid substance and may be seen by using a powerful microscope.

The Cells in the Structure of a Plant.—Plants resemble animals in very many respects. The plant body is composed of many forms of microscopic cells, each kind having its own function to perform in the life processes of the plant. The cell is surrounded by a *wall* which encloses the *cytoplasm* and the *nucleus*. In plant cells there are usually spaces filled with *cell sap*, and embedded in the cytoplasm are the minute *chlorophyll bodies*.



A plant cell. (Draw.)

Growth in Plants.—Growth is the result of an increase in the size of the cells that compose the body of the plant and the production of new cells. The new cells are formed by a division or breaking in two of the old cells. During this process the nucleus of the cell divides into two parts, which move to opposite ends of the cell. A partition then forms across the cell, which finally separates to produce two new cells.

Storage of Starch.—Carbohydrates not needed at once by the plant are stored, usually as starch, for future use.

Exercise.—Name the various parts of plants in which you know that starch is stored. Test a potato, a carrot, an onion for the presence of starch. Notice how these parts are modified and enlarged to make suitable storehouses. Give reasons for the storage of starch. Do annuals store starch? What plants do?

When starch is stored in any part of the plant, the part becomes larger. The large fleshy roots of the carrots, turnips, parsnips, etc., are good examples. The leaves of onions and cabbages are thick and fleshy because of the quantities of starch stored in them. Potatoes are underground stems. (See page 59.) Notice how swollen they

are with their supplies of starch. Starch may be stored in leaf, stem, or root. As the plant matures the starch is moved from its place of storage and gradually finds its way into the seed.

Stomata or Breathing Pores.—How do the gases, carbon dioxide and oxygen, pass in or out of the leaf? From what part of the leaf does transpiration take place?

Exercise.—By means of a sharp knife carefully remove a small piece of the epidermis from the under-side of a fresh geranium leaf. A piece about $\frac{1}{16}$ inch square is more than enough. Prepare a slide from it and examine, first under the low-power lens of a microscope, and then under the high-power lens.

To prepare the slide, carefully clean the cover-glass and slide. Place the piece of epidermis on the slide, and with the point of a pen-knife drop a small quantity of water on it. Then carefully set the cover-glass over the material and gently press it with the knife to squeeze out any air bubbles that may have been formed. The slide is now ready for the microscope. Make a drawing of it, naming all the parts.

Notice the large number of tiny openings in the epidermis. They are surrounded by two semi-oval-shaped cells. Is there any coloring matter or chlorophyll in any cells that you see? What is its appearance? What shape are the cells of the epidermis? Do they contain chlorophyll?

The minute openings are the breathing pores of the leaf and are known as *stomata* (sing., *stoma*). There are usually thousands to the square inch, especially on the under-side of the leaf. The stomata are opened and closed automatically, as the requirements of the leaf vary, by the *guard cells* that surround them. The guard cells contain chlorophyll—in the minute green particles which you saw under the microscope.

The Structure of a Leaf.—The foregoing exercise demonstrates that it is not difficult to peel the *epidermis* from a leaf. It is transparent and does not contain chlorophyll. Its purpose is to protect the soft cells beneath it and to

prevent the evaporation of too much water from the leaf. Below the epidermis of the upper side are long *palisade* cells. Beneath these are very irregular-shaped cells of the *spongy layer.* These cells have numerous air spaces between them. Below the spongy layer is the lower epidermis. Both the upper and the lower epidermis are pierced by the stomata. The palisade cells, the spongy layer, and the guard cells contain the small bodies in which is found the

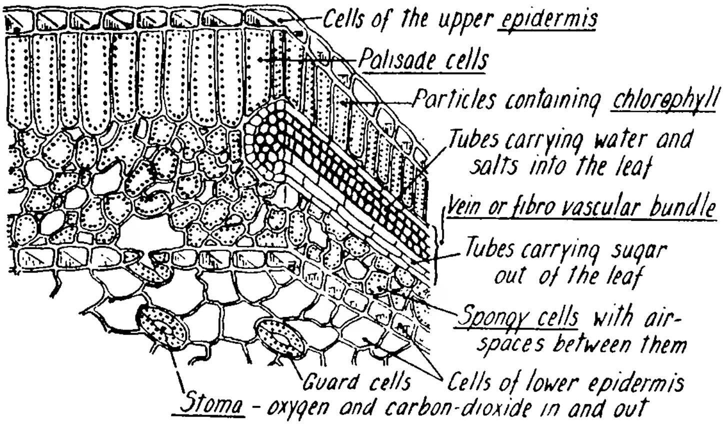


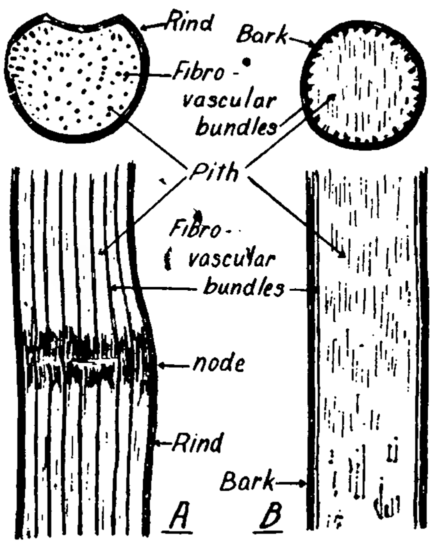
Diagram illustrating the structure of a leaf. A cross-section, a lengthwise section, and the lower surface are shown. (Draw.)

chlorophyll. Running between the cells already mentioned are the cells that form the veins. The veins are continuations of the fibro-vascular bundles of the stem.

The Stem.—Fibro-vascular Bundles.—The leaves and roots are the workshops of the plant. The stem serves to convey the raw material or the finished product from one workshop to the other as the plant requires. Some stems are also storehouses for reserve food supplies. If a stem is examined under a microscope, it will be found to be composed of cells, as are the other parts of the plant. The

cells that transport food material are arranged end to end to form long tubes that run through the stem to and from all parts of the plant. These tubes are grouped into bundles called *fibro-vascular bundles.* In these bundles are also growing cells and others that strengthen the stem. There are two kinds of stems depending upon the arrangement and nature of the fibro-vascular bundles.

Endogenous Stems.—**Exercises.**—(1) Carefully examine cross and lengthwise sections of a corn stalk. Notice the fine, thread-like parts. These are the *fibro-vascular bundles,* and are composed of numerous microscopic cells or tubes. Observe that they are not in any definite arrangement. The white spongy material between the bundles is the *pith,* which serves chiefly to fill up space. Look for the solid *joints* or *nodes* in the stem. Suggest a purpose for these. At each node some of the fibro-vascular bundles are turned outward to connect with the vascular system of the leaves.



A, the endogenous stem of the corn. B, the exogenous stem of the sunflower. (Draw.)

(2) Place the ends of some young, freshly cut corn stalks in some diluted red ink. After several hours cut slices from the stem and examine to determine the parts through which the water rises.

(3) Examine the stems of some grasses and grains. Look for the nodes. Notice that these stems are hollow.

Stems like the corn stalk grow by pushing up new fibro-vascular bundles through the pith, and are called *inside growing* or *endogenous.*

Exogenous Stems.—**Exercises.**—(1) Examine lengthwise and cross sections of the stem of a sunflower and of a tree. Observe the row of fibro-vascular bundles that extend around the stem of the sunflower. Are there bundles scattered around the pith? The bundles in the tree stem are not as easily located, but it is readily seen that they are arranged in *rings*. Notice that, as the rings have developed, the *pith* has been crowded into a small space in the centre. Observe that the *old rings* around the pith are hard and woody and do little else than strengthen the stem. Examine carefully the last or outside ring. This and the inner bark are the most active parts of the stem. In the green outside part of the last ring are the *growing cells*, and this

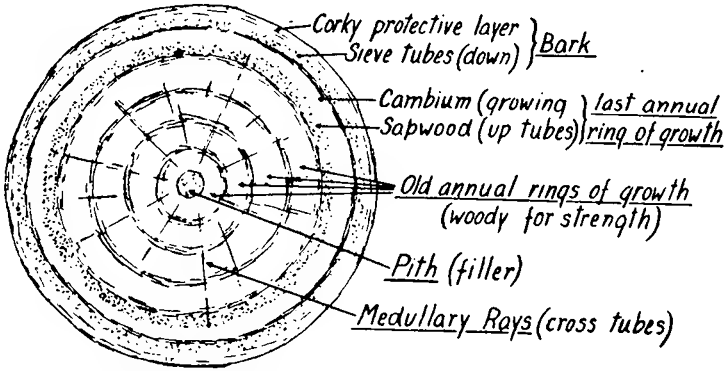


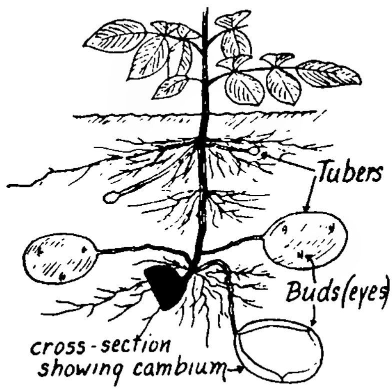
Diagram to illustrate the parts of the exogenous stem of a tree. (Draw.)

part of the stem is called the *cambium*. The inside part of the last ring is the *sapwood* and contains the *up-tubes* that carry raw sap from the roots to the leaves. Peel the bark from the stem or branch of a tree. Notice how loose it is, and how green and moist are the inner part of the bark and the wood just beneath the bark. The green *inner-bark* is composed of fine passages called *sieve tubes*. These are the *down-tubes*, which carry manufactured food from the leaves to the lower parts of the plant. The *outer corky part of the bark* serves to protect the inner parts of the stem. Radiating from the centre of the stem are narrow layers of cells called *medullary rays*, which transport food across the stem.

(2) Stand the ends of freshly cut young maple or poplar stems in diluted red ink. After several hours examine to determine the parts through which the sap rises.

In the stems of trees, sunflowers, and many other plants the fibro-vascular bundles are arranged in rings. If these plants live for more than a year, the stems increase in diameter by the addition each year of a new ring of growth to the outside of the old rings. These stems are called *outside growing* or *exogenous*.

The Difference between Roots and Stems.—Underground Stems.—**Exercise.**—Look for buds on roots. Observe the buds (eyes) on a potato. Roots do not normally bear buds. The potato is, therefore, an underground stem. The rootstock of the thistles and some of the perennial grasses are underground stems. Why? Some plants have aerial roots. How would you distinguish such roots from the stems of the plant?

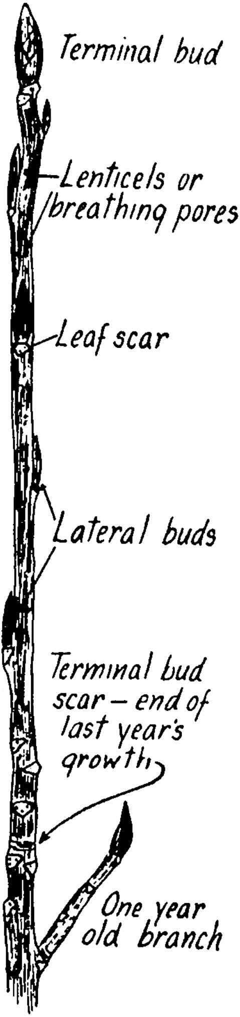


The root system and tubers of the potato. The tubers are not roots, but are the swollen ends of underground stems. Why? (Draw.)

Buds. — Leaf Scars. — Exercises. — (1) Gather some branches bearing buds and leaves. Notice that the arrangement of the buds, leaves, and branches is the same. Observe that most buds contain miniature stems and leaves. Other buds develop into flowers, or a stem with leaves and flowers may be produced by the same bud. Notice the gummy, water-proof covering of tiny scales. Buds are formed in the spring soon after the leaves become full grown.

(2) Pull some of the leaves from a branch. Observe the scar that is left. At the upper end of the scar there is a tiny bud which will later develop into a branch. The leaf was produced in the bud that caused the scar. Examine the end of the leaf petiole and the leaf scar for the ends of the fibro-vascular bundles that extend from the stem into the leaf.

Flowers.—The function of the flower is to produce seed in order to reproduce the plant. Not all plants bear



A poplar twig. Notice the ends of the fibro-vascular bundles in the leaf scars. (Draw.)

flowers, but, if seed is produced, there must be flowers. Perhaps there are plants that you believe have no flowers because you have overlooked them. All flowers are not large and showy. Look for the flowers of grasses and trees in the spring.

The Structure of a Flower.—**Exercise.**—Obtain flowers from the following plants: sweet pea, nasturtium, petunia, and nicotiana. These are suggested because they are large and easily examined. Others should be observed later. On the outside, just above the stem, will be found the green *calyx*. The divisions of the calyx are called *sepals*. Are they separated or united? The purpose of the calyx is to protect the parts of the flower that produce the seed. The showy, colored part is the *corolla*. The parts of the corolla are known as *petals*, and, like the sepals, they may be united or separate. Inside of the corolla observe the *stamens*. Count them in each flower. The top of the stamen is the *anther*, which produces the *pollen*. The slender stalk that supports the anther is the *filament*. Look for the *pistil* in the centre of the flower. The head of the pistil is the *stigma*. What do you observe upon touching it? The stalk is the *style*, and the lower part is called the *ovary* or *seed case*. Cut across the ovary of a large flower. How many compartments are found? Notice the one or more small white bodies in the ovary. These are *ovules*, which, after pollination and fertilization have taken place, develop into seeds. They may be readily seen by carefully removing the stamen tube from around the pistil of the sweet pea and holding the ovary against the light. How many ovules are there in the

ovaries of the flowers which you have examined? Make labelled drawings of these flowers.

Pollination.—Before the flower can produce seed the pollen must be transferred from the anther to the stigma. Flowers are assisted in the act of pollination chiefly by numerous insects and the wind. Many flowers, such as those of wheat and oats, are *self-pollinated*; that is, the anther pollinates the stigma of the same flower. However, most flowers encourage *cross-pollination*, or the transfer of pollen from the anther of one flower to the stigma of another flower of the same kind. The *staminate* and *pistillate* flowers of the corn are splendid examples of flowers that are arranged to prevent self-pollination. Staminate flowers have no pistils, and pistillate flowers lack stamens. The cucumbers, mallows, squash, etc., have staminate and pistillate flowers.

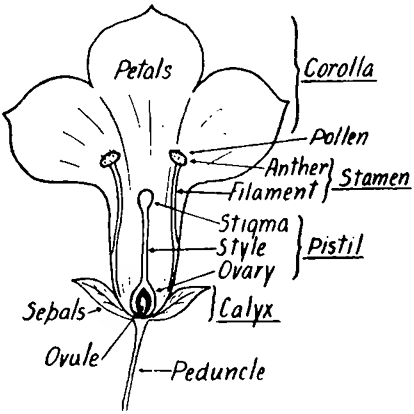


Diagram to illustrate the parts of a flower. (Draw.)

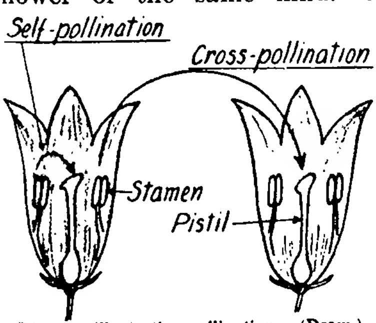


Diagram illustrating pollination. (Draw.)

Exercises.—(1) Why do some flowers have a brightly colored corolla or a strong perfume? Suggest a purpose for the sweet, honey-like *nectar* found in the bottom of the flower-cup, or in the spur of such flowers as the nasturtium. What insects do you observe

around the flowers? How do they carry pollen from flower to flower?

(2) The flowers of the grasses and of such trees as the ash, elm, maple, etc., are without bright colors, perfume, or nectar. Have these flowers need of these characteristics? How are they pollinated?

(3) Flowers are frequently cross-pollinated by man. Suggest reasons for artificial pollination.

Project.—Make a study of the methods by which plants encourage cross-pollination. Observe carefully the flowers of such plants as the nasturtium, snapdragon, dandelion, corn, willows, and others.

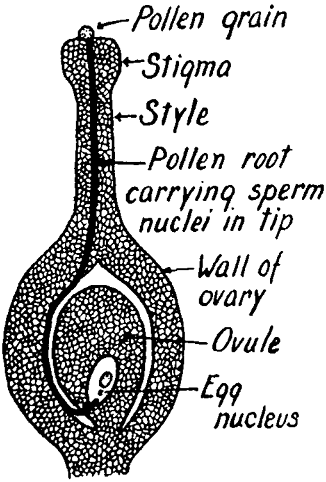


Diagram illustrating fertilization. (Draw.)

Fertilization.—After the pollen is caught by the stigma, it produces a microscopic tube, which finds its way down through the style to the ovary. Near the tip of this minute *pollen tube* there are two minute *sperm cells* or *nuclei*. The ovule encloses another *nucleus* or *egg cell*. When the pollen tube reaches the ovule, the sperm nuclei and the egg nucleus unite. The ovule is thus *fertilized*, after which it develops into a seed. Fertilization can take place only when pollen from the same kind of plant, or one very closely related, falls on the stigma, for example, wheat pollen on a wheat flower.

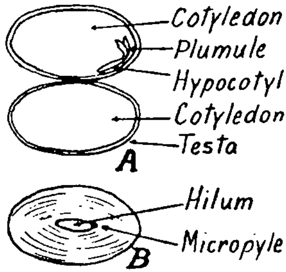
The Fruit.—**Exercise.**—Compare flowers that are faded with fresh ones of the same kind. Stand some sweet peas in water and observe them carefully as they wither. Which parts die first? Notice the pistil closely. Which parts of it wither away, and which parts grow larger? Give reasons for the changes that occur in the flower.

As the seeds develop, the walls of the ovary expand, and finally a fruit is produced. In its simplest form the fruit

is the ripened ovary and its contents (the seeds). There are two general classes of fruits, dry and fleshy. The *dry fruits* are: the *nuts*; the *winged seeds* of the maples; the *grains* of wheat, oats, and corn, etc.; and the *pods* of the beans, peas, mustards, turnips, etc. The *fleshy fruits* include: the *berries*, oranges, lemons, pumpkins, squash, melons, currants, goose-berries, tomatoes, etc.; the *drupes* or *stone fruits*, peaches, plums, cherries, etc.; *pomes*, apples, pears, etc. Strawberries, raspberries, blackberries, etc., are not true berries but are fruits of a special nature.

Seeds.—A seed is a baby plant surrounded by a supply of starch and other foods. It is the beginning of the plant and at the same time the ultimate end of all plant activity.

The Bean Seed.—Dicotyledonous Seeds. — **Exercises.** — (1) Soak some bean seeds over-night, then carefully examine the *outside characteristics*. Notice the scar, called the *hilum*, where the seed was attached to the pod. Observe in one end of the hilum a tiny opening, the *micropyle*, through which the seed first absorbs water.



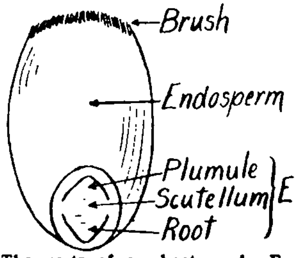
The parts of a bean seed. A, the inside. B, the outside. (Draw.)

(2) Carefully remove the seed coat or *testa* and examine the *inside parts* of the bean. Notice that the seed readily splits into two parts called *cotyledons* or *seed leaves*. Between the cotyledons and near one end look for a tiny plant. The minute, leaf-like parts are the *plumule*, which grows into the stems and leaves of the new plant. Below the plumule observe the *hypocotyl*, which produces roots as the seed germinates. The plumule, hypocotyl, and cotyledons are together known as the *embryo* or *germ* of the seed.

(3) Drop a little iodine on the cotyledons, and after a few minutes observe the color that develops. Apply the test for protein outlined on page 190. Suggest a use for the stores of starch, protein, etc., that are found in the cotyledons.

Seeds like the bean are called *dicotyledons* (*di*, two; *cotyledon*, seed leaf).

A Kernel of Wheat. — Monocotyledonous Seeds. — Exercise.—Soak some wheat seeds over-night, then examine them. Observe the *embryo* at one end of the seed. Look carefully for parts that you can identify as the *plumule* and the young *root*. Packed in behind the embryo is a large supply of food called the *endosperm*. Test the endosperm for starch. Is there an endosperm in dicotyledonous seeds? Notice that between the embryo and the endosperm there is a single cotyledon called the *scutellum*. The purpose of the scutellum is to absorb and digest food from the endosperm and carry it to the embryo.



The parts of a wheat seed. E, embryo. (Draw.)

Seeds with one cotyledon are known as *monocotyledons*. The single cotyledon never appears above the ground, as the cotyledons of some of the dicotyledons do, but remains underground in contact with the endosperm.

Germination of Seeds.—Under favorable conditions the embryo in the seed awakens, and a new plant is produced. The seed first absorbs water, then swells and breaks the seed coat. The starch in the seed is changed to sugar, upon which the embryo feeds. The plumule is lifted up to the light, and the root grows downward, producing secondary roots. Soon true foliage leaves develop, and the cotyledons disappear. Germination is not complete until the young *seedling* is capable of taking care of itself.

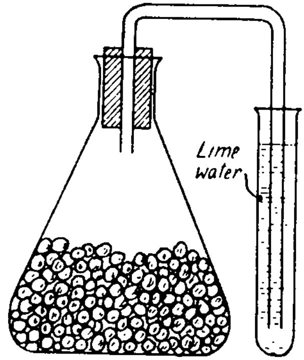
Exercises.—(1) Bury a few dry seeds in dry sand. Place others in moist sand or soil. Keep both lots in a warm location. Watch the seeds from day to day. Which condition is favorable for germination?

(2) Place two lots of seeds in moist sand or soil. Set one lot in a warm room and the other in a refrigerator. Give reasons for results.

(3) Place seeds in two similar wide-mouthed bottles. Cover one lot with a few inches of sand and keep moist. Cover the others with water that has been boiled to drive out the air, and cooled. Seal

the second bottle air-tight. Account for any difference in the germination of the seeds.

(4) Germinate half a pint or more of seeds in the bottom of a wide-mouthed bottle. Complete the apparatus as in the illustration. Filter some lime-water into the test-tube. Set the apparatus away over-night. The development of a milky appearance in the lime-water indicates that the seeds are producing carbon dioxide.



An experiment to see if seeds produce carbon dioxide during germination. (Draw.)

(5) Remove the food supplies (the cotyledons of beans and the endosperm of corn or wheat seeds). Plant the embryos along with others from which the food supplies have not been removed. Which grow? Account for the result.

(6) Plant some large and small seeds of various kinds in a tall jar. Place some of each near the bottom and others at intervals up to within half an inch of the top. Keep the soil moist. Which seeds succeed in germinating and producing new plants from the greatest depth? What seems to be the best depth for the various kinds of seeds which you have under observation? Why can the seedlings from small seeds not reach the surface when the seeds are planted too deep?

(7) Plant various kinds of seeds in a box of sand or sawdust. Keep the soil moist. Watch how the different seeds break through the seed coat. Take some up from time to time, and notice how they germinate. Observe the young plants as they appear above the surface. Which seedlings raise the cotyledons above ground? What happens to the cotyledons as the seedlings develop?

Plant Families.—**Exercise.**—Gather specimens of the plants mentioned in the following groups: Group I—wheat, oats, barley, rye, several kinds of grasses, wild oats, and corn. Group 2—peas, beans, alfalfa, sweet peas, caragana, vetch, etc. Group 3—turnip, cabbage, several mustards, radish, cauliflower, etc. Examine the plants carefully in detail as follows: root—fibrous, tap, rootstock; stem—hollow, jointed, erect, trailing, juicy, etc.; leaf—simple, compound, netted-veined, parallel-veined, entire, divided, odor, juicy,

attachment to branch; flower—simple, composite, general shape, number and arrangement of sepals, of petals, of stamens, and of pistils, staminate, pistillate, infloreseence, etc.; seed—shape, tufted, covering, kind of pod, etc. Tabulate your observations as below:

Plant	Root	Stem	Leaf	Flower	Other Observations
Group 1..					
Peas.....					
Beans....					
Etc......					
Group 2..					
Wheat....					
Oats.....					
Etc......					

Observe that many of the characteristics of the plants in each of the foregoing groups are very much alike. Do the characteristics observed to be common to the plants of one group seem to be confined to that group only?

Plants have been grouped into a large number of *plant families.* The flowers, leaves, seeds, and other parts of the plants in each family closely resemble each other.

Classification of the Plant Kingdom

- Plant Kingdom
  - Non-flowering Plants
    - (*a*) Algae, fungi, bacteria.
    - (*b*) Mosses.
    - (*c*) Ferns, club mosses.
  - Flowering Plants
    - (*a*) Plants whose seeds are not enclosed in ovaries; pines, spruces.
    - (*b*) Plants whose seeds are enclosed in ovaries.
      - Monocotyledons—Plants whose seeds have one seed leaf.
      - Dicotyledons—Plants whose seeds have two seed leaves.

Most of the plants with which we are most familiar on the farm or in the garden are monocotyledons or dicotyledons.

The Monocotyledons.—This group of plants, as you will have already found, have the following characteristics in common: one seed-leaf or cotyledon in the seed, parts of flowers in threes, long slender parallel-veined leaves, tight bark, and endogenous stems.

Gramineae or *Grass Family.*—This is one of the most important plant families. It includes wheat, oats, barley, rice, and other cereals, the grasses, corn, sugar-cane, millets, and sorghums. Stems are usually hollow and jointed. Leaves are alternate, long, slender, parallel-veined, and sheathe or wrap themselves around the stem from joint to joint. Flowers are green colored and arranged in spikes (wheat, western rye grass) or panicles (oats, brome grass). The parts of the flowers are in threes. Roots are usually fibrous. Some members of this family have underground stems (brome grass, red top, Kentucky blue grass).

Liliaceae or *Lily Family.*—Apart from the characteristics in common with the other monocotyledons, the members of this family are distinguished by their bell-shaped flowers. Many of them are reproduced from bulbs. To this family belong the onions, asparagus, lilies, hyacinths, trillium, smilax, etc. The leaves of the trillium and smilax are netted-veined.

The Dicotyledons.—Plants in this group are distinguished from the monocotyledons by the following characteristics: dicotyledonous seeds, netted-veined leaves, parts of flowers in fours or fives, bark loose during the growing season, and exogenous stems.

Leguminosae or *Pea Family.*—The leaves of this family are compound. The flower resembles the sweet pea, having 5 irregular petals and 10 stamens, 9 united and the tenth separate. The seed is contained in one-celled pods or legumes. Nodules are found on the roots. The family includes peas, beans, clovers, alfalfas, vetches, caragana, and loco weeds.

Cruciferae or *Mustard Family.*—The parts of the flowers are in fours, forming cross-shaped flowers. The seeds are held in pods

divided into two parts. The pods usually break open when ripe. Another characteristic common to this family is the pungent watery juice that they contain. Many of our worst weeds, such as Frenchweed, shepherd's purse, false flax, and all the mustards belong to this family, which also includes radishes, turnips, cauliflowers, cabbages, and cresses.

Rosaceae or *Rose Family.*—The flowers of this family possess its chief distinguishing marks. They are regular in shape. The corolla contains 5 petals. The stamens are numerous and grouped around one or more pistils. The members are herbs, shrubs, and trees, including peach, plum, cherry, apple, pear trees, blackberries, raspberries, strawberries, saskatoons, roses, and similar plants.

Chenopodiaceae or *Goosefoot Family.*—The leaves are thick and coarse. The flowers are minute, dull green, and crumb-like. The seeds are contained in the calyx, which remains around the seed like a paper sac. The family includes the beets, mangels, spinach, and some common weeds such as Russian thistle, Russian pigweed, and lamb's quarters. The redroot pigweed does not belong to this family but to one closely related called Amaranthaceae or Amaranth Family.

Umbelliferae or *Parsley Family.*—The flowers are small and borne in umbels. An umbel is an arrangement of flowers like an umbrella. The leaves are deeply cut and aromatic. Some plants are poisonous. The pistil has two ovules although the seeds separate when ripe. The seeds are ribbed. Representatives of this family are: carrots, parsnips, celery, parsley, caraway, water hemlock, and wild parsnip.

Compositae or *Daisy Family.*—This is a large family including many of our most troublesome weeds. The flowers are arranged in heads as in the sunflower and are composed of many small florets. Make a study of a sunflower. The seeds are tufted and float long distances in the wind. Among the members are the thistles, dandelions, asters, daisies, goldenrods, sunflowers, lettuce, salsify, and chicory.

Solanaceae or *Nightshade Family.*—This family includes such plants as the potato, tomato, tobacco, peppers, jimson weed, and others. The leaves are strongly scented. The flowers are regular and wheel-shaped. The fruit is a two-celled, many-seeded berry.

Cucurbitaceae or *Gourd Family.*—The stems are weak and trailing, with tendrils for climbing. The flowers are staminate and pistillate, and the two forms may be on the same or on different plants. The seeds are large and flat and contained in hard-coated berries. The family includes melons, squash, cucumbers, pumpkins, citron, and vegetable marrows.

We have considered exceedingly briefly a very few of the more common plant families of farm and garden. There are some hundred or more classified. The student who wishes to become better acquainted with the families of plants should secure a good reference and identify and classify in the correct family all the plants with which he is not familiar.

CHAPTER V

FIELD CROPS

Classification of Field Crops.—Field crops are classified according to use as follows:

Cereals—grasses produced for grain—wheat, oats, barley, rye, corn, rice, etc.

Forage crops—crops for feeding live stock.

(*a*) Hay crops—fed dried or cured—grasses, legumes, millets, oat sheaves, corn, etc.

(*b*) Pasture crops—harvested by animals themselves—chiefly the same crops as for hay.

(*c*) Soiling crops or green feed—cut green and fed to live stock immediately—corn, or any leafy quick-growing crop.

(*d*) Silage crops—preserved in a silo by the exclusion of air—corn, oats and peas, alfalfa, sweet clover, sunflowers, etc.

(*e*) Fodder crops—the leaves and stems of threshed grains, legumes or grasses.

Fibre crops—produced for fibre—flax for linen, hemp for rope, cotton for cotton, etc.

Oil crops—flax for linseed oil—castor bean for castor oil, etc.

Sugar crops—sugar-beets, sugar-cane, etc.

Cleaning crops—produced to destroy weeds—inter-tilled crops, summerfallow, early maturing crops, etc.

Restorative or improvement crops—grown to improve the soil—grasses to restore humus, legumes as nitrogen restorers, sweet clover as a green manure, etc.

Wheat.—Wheat is Canada's chief source of wealth. Some 400,000,000 bushels, valued at $450,000,000, are produced annually. Most of this enormous crop is grown upon the western prairies.

Canadian wheat is renowned throughout the world for its excellent bread-making qualities. Consequently it

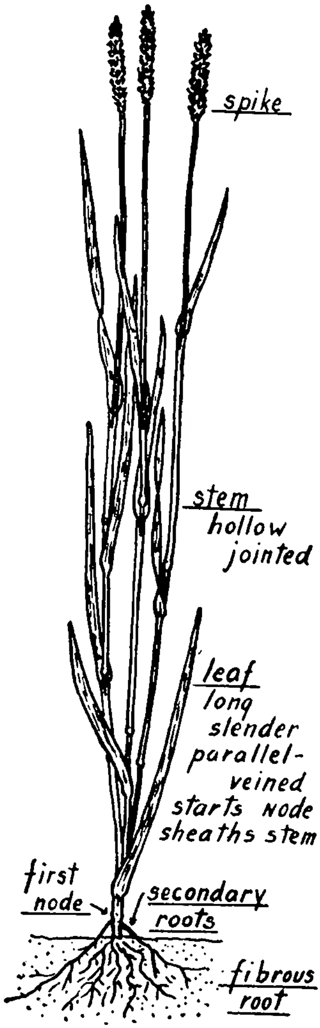
is in great demand in the United States, Great Britain, France, and Southern Europe. These countries require it for mixing purposes. Their own wheat is soft and starchy, but, when mixed with the right proportion of Canadian wheat, it produces a good bread-making flour. China and Japan also import large quantities of our wheat. Canada now exports more wheat than any other country in the world.

Exercise.—(1) Secure wheat plants for examination. (Note to teachers.—The plants may be gathered in the fall, root and all, and stored for use during the winter. Tie into a sheaf and suspend from the ceiling to protect from mice.) Briefly summarize the characteristics of each part as you examine it.

Stem.—Is the stem hollow? Notice the joints or *nodes* at intervals along the stem. Are the nodes hollow? Can you suggest a use for these solid joints in the long, slender, hollow stem?

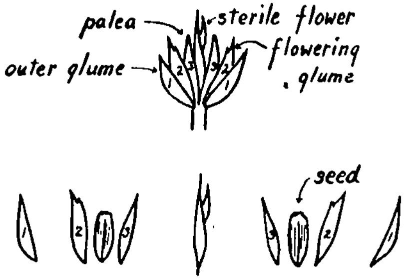
Root.—Are the roots fibrous or tap? Does the wheat root system appear to be dense enough to add humus to the soil? Look for a secondary set of roots springing from the first node of the stem.

Leaf.—What shape is the leaf? Are the veins parallel or netted? From where does the leaf start? Notice how the lower part of the leaf



A typical wheat plant.
(Draw one stem.)

wraps or sheathes itself around the stem. How far from the joint from which it grows does the leaf continue to clasp the stem? Observe how the leaves are arranged along the stem. The wheat leaf is typical of all grass leaves.



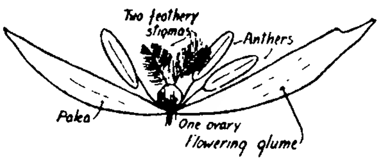
A spikelet of wheat; above, complete; below, dissected. (Draw.)

Inflorescence.—The arrangement of the wheat flowers is known as a *spike*. The sections of the spike are spikelets. Notice how they are arranged, back to back, alternately along the stalk. Remove several spikelets and examine the stalk that supports them. Observe its zig-zag appearance. It is called the *rachis*. Do the ends of the spike bear seeds?

Spikelet.—How many kernels do you find in each spikelet? Some in the class may find three or even more, but two is the most common number. Every kernel represents a flower. Notice how each spikelet, even with only 2 seeds, seems to have had 3 flowers. When only 2 kernels are produced the centre flower was sterile.

Dissect a spikelet. Carefully remove each part in turn, starting at one side of the spikelet. Place all parts as removed on a sheet of paper in the same order as separated from the spikelet. There should be 9 parts as follows: the *outer glume, flowering glume, kernel,* and *palea* of one fertile flower; a *sterile flower*; the *palea, kernel, flowering glume,* and *outer glume* of the other fertile flower.

Four-rowed wheat and *six-rowed wheat.*—When each spikelet produces 2 seeds, there will be 2 rows of kernels from top to bottom on each side of the spike, or 4 rows in the whole spike. Three seeds to the spikelet would be 3 rows on each side of the spike or a total of 6 rows.



A wheat flower (much enlarged and, spread out to show the parts). Each spikelet in a head of wheat consists of from 3 to 5 flowers, with empty glumes below. (Draw.)

Flower.—The wheat flower should be examined early in the summer. It is small and green and consists of the palea and the glumes, 3 stamens, and one pistil with a broad feathery stigma.

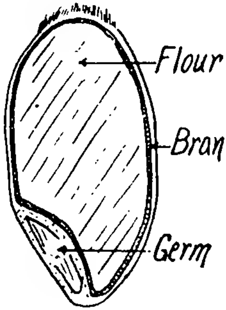
Seeds.—Observe the tuft of fine hairs at the top of the kernel.

Compare the two sides. One is deeply creased. The other is smooth. At the base of the smooth side is found the *germ* or *embryo.*

(2) Draw the entire wheat plant. Show plainly how the leaves sheathe the stem. Name each part.

(3) Make three drawings of a wheat kernel, *i.e.*, crease side, germ side, and cross section. Name all parts.

(4) Wheat belongs to the Gramineae or Grass Family. Refer to the notes on plant families (page 67), and compare the general characteristics of this important family with your observations on the wheat plant. Write a list of the other plants in the family.



A lengthwise section of a wheat kernel. (Draw.)

Uses of Wheat and Influence of Climate upon its Quality.—A short, hot growing season and a moderate rainfall produce in Western Canada a wheat with a hard translucent kernel, that has a world-wide reputation for its bread-making qualities. In warm, humid climates the wheat ripens slowly and is yellow, soft, and starchy. Such wheats are useful for pastry, breakfast foods, and brewing or distilling purposes. Macaroni is produced chiefly from the Durum wheats. Wheat is also used for feeding live stock and poultry. What use has wheat in a crop rotation? (See page 25.)

Bread-making Quality of Wheat.—**Exercise.**—Moisten some flour to make a stiff ball of dough about the size of an egg. Allow it to stand for $\frac{1}{2}$ hour. Now tie around the ball a cloth to form a small bag. Place the bag in a vessel of water and work the dough vigorously with the fingers. Change the water at intervals and continue kneading the dough until the water remains clear.

Into some of the water in which the dough has been washed pour a few drops of iodine. What does the resulting color indicate?

Upon opening the bag you will find a soft gummy substance. Try its elasticity by stretching it. It is called *gluten* and is the secret of the bread-making quality of flour. Gluten is a protein. What important plant constituent will it, therefore, contain? Try separating the gluten by chewing wheat.

In the making of bread, yeast is thoroughly kneaded into the dough, which is then placed in a warm place to "rise". In the presence of heat and moisture the yeast plants grow and produce carbon dioxide. The gas forms bubbles or cavities in the dough. When there is gluten in the dough, the walls of the cavities are capable of being stretched. As more carbon dioxide is produced, the

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Varieties of wheat. Kubanka is a Durum or Macaroni wheat; the other three are classed botanically as Common wheats. Notice that there are bearded varieties in both classes. What are the botanical differences between Common and Durum wheat? Turkey Red is a winter wheat; the others are spring-sown varieties.

cavities grow larger, and the bread "rises". If gluten had not made the dough elastic, the walls of the gas pockets would break instead of stretching. The heat of the oven drives out the moisture and the carbon dioxide and "sets" the walls of the cavities. Examine a slice of bread and observe the cavities.

Classification of Wheats.—There are many classes of wheat as follows: *hard* or *soft*, on a texture basis; *red*, *white*, or *amber*, when color is considered; *spring* or *winter*, accord-

ing to the time of year sown; *Common, Durum,* etc., when classified botanically; *bread* or *macaroni* wheats, from a utility standpoint. It is better, for our purpose, to consider these classifications collectively.

Varieties of Wheat for Western Canada.—Exercise.— Obtain threshed samples: of some Common hard red wheats, such as Marquis, Red Fife, or Ruby; of winter or any soft wheat, such as Turkey Red or Kharkov; of white wheat, such as White Fife or White Bobs; and of Durum wheats, such as Kubanka or Pelissier. Examine the berry (kernel) and tabulate your observations as follows:

Variety.
Class: Common, Durum, etc.
Sown: fall, spring.
Shape: long, slender, short, broad, pointed, blunt.
Color: red, white, light or amber, yellow.
Texture: hard, soft, white and opaque, translucent (test by biting).

The hard, translucent kernels are high in gluten content. Yellow, soft white berries are starchy and low in gluten.

Marquis is a Common spring wheat very widely grown in Western Canada. The kernel is red, short and broad, translucent, and high in gluten. It excels for bread-making.

Red Fife is another popular Common spring wheat. The berry is a little longer and more pointed than Marquis. Red Fife is a bread-making wheat but is later maturing than Marquis.

Ruby is a Common beardless wheat of good bread-making quality. Because of its early-maturing qualities it is grown in the northern districts, where early fall frosts occur.

Durum or *Macaroni* wheats are bearded spring wheats, high in gluten; but, as the gluten is of low quality, they are used largely for making macaroni. Their popularity in Western Canada is due chiefly to their ability to resist rust,

drought, and shattering to a higher degree than Marquis, Red Fife, and other Common wheats. The most common varieties in Western Canada are Kubanka and Pelissier.

Production.—A well-drained clay loam is the best type of soil. Wheat is usually sown as the first and second crops after breaking, summerfallow, or corn. On drier lands "stubbling in" is a cheap method and often satisfactory if the land is clean. Wheat requires an abundant supply of moisture. Where wheat is to be sown on stubble, the heavier lands are better plowed in the fall to a depth of 5 or 6 inches to benefit from fall rains and the frost, which aids in pulverizing them. Lighter land is usually plowed in the spring and shallower. Harrowing immediately after the plow is advisable to pulverize the surface and prevent the loss of moisture. In some districts, stubble land and summerfallows are now being prepared for wheat without the use of the plow and harrow. Such implements as the broad-toothed cultivator leave the land lumpy and in less danger of drifting. What is the practice in your dis-

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The development of a wheat plant, showing (1) and (2) the stage of leafing and tillering, (3) in the "shot blade", (4) flowering and fertilization, (5) the filling stage, and (6) ripe.

trict? (See page 39.) The lighter soil is often packed either before or after seeding.

The seed should be well cleaned by a fanning mill to remove weed seeds, etc. If there is any doubt of the viability (life) of the seed, it should be tested for germination. It should also be thoroughly disinfected for smut. (See page 143.)

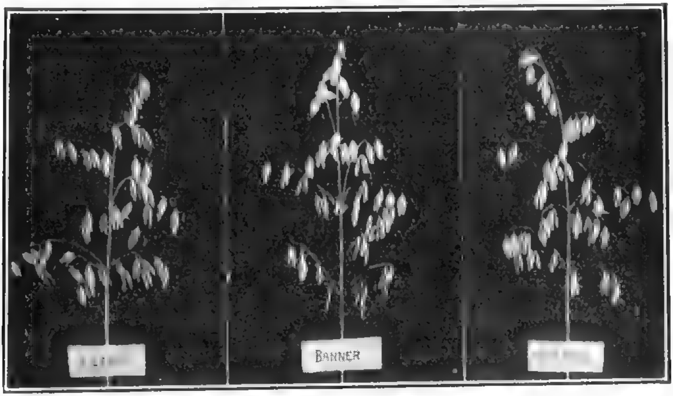
Wheat should be sown, at the rate of one to two bushels per acre, as early as soil and weather conditions are suitable. Early sowing reduces the danger of rust and early fall frosts. The depth to which the seed should be placed, usually 2 or 3 inches below the surface, depends on the soil and season. The seed must be sown deep enough to be down to moisture. Why?

Sometimes the land is packed after seeding. More often the soil is harrowed after the crop has reached a height of 5 or 6 inches. The latter method helps to destroy annual or winter annual weeds in the crop and conserve moisture.

Wheat should be cut just before the kernel is ripe—in the stiff dough stage or just hard enough to be dented by the thumb nail. If cut too early, the kernel will shrink, while if the grain becomes too ripe, it shells out badly. It is cut with a binder, tied into medium-sized sheaves, and finally stooked in shocks of 8, 10, or more sheaves. The object of stooking grain is to allow food in the stem to pass into the seed, to dry the plant for threshing, and to protect the kernels from the dampness of the ground. As soon as the grain is ready it should be threshed. A delay in threshing may be the cause of the grain being damaged by rain or snow. When this occurs, the color of the berry is often injured, or the grain sprouts, either of which will reduce the grade. If it is not possible to thresh the grain at once, it is often stacked to protect it.

Oats.—In general characteristics, oat plants resemble wheat very closely. The inflorescence, however, is a *panicle* instead of a spike. The drawings on page 72 also represent oat spikelets and flowers.

Oats are used for feeding live stock, as concentrates, hay (green or sheaf feed), or silage. Breakfast foods, such as rolled oats, are manufactured from the kernel. The feeding value of oats depends to a large extent upon the thickness of the hull, which forms from 25 to 40 per cent of the entire seed. The varieties of oats most commonly grown are: *Banner*, *Victory*, and *Gold Rain*.

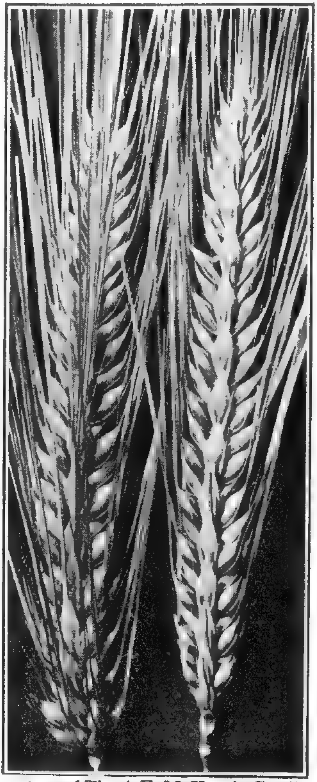


Courtesy of The Grain Growers' Guide, Ltd.

Three of the leading varieties of oats in Western Canada; Victory, Banner, and Gold Rain. What varieties of oats are grown in your district ?

Oats grow best in districts with an abundant rainfall and where a loose loamy soil predominates. They are sown usually after wheat in the rotation. Seeding is done, at the rate of 2 to 3 bushels per acre, up to about May 20th. In the production of oats the same cultural practices as those that have been outlined for wheat are followed to a large extent.

Barley.—Barley is the grain most generally used in Western Canada for fattening live stock. The kernel contains a high percentage of carbohydrates. (See page 191.) This cereal is important as a cleaning crop. Its early-maturing qualities make it valuable to prevent such weeds as wild oats from scattering seeds. Barley is also used for malting purposes.



Courtesy of The A.E. McKenzie Co., Ltd.

Heads of six-rowed barley. There are many types of barley. The two most widely grown in the West are the six-rowed and the two-rowed. Explain these terms.

Fall or Winter Rye.—This is a winter annual. It is sown in the fall and harvested early the following summer. If sown early, it provides a splendid fall pasture. It is also very useful to prevent soil-drifting in fall and spring and is widely grown for that purpose.

Flax.—Flax seed is the source of linseed oil, which is used in the manufacture of paints, linoleums, and other products. The remainder of the flax seed, after the oil is extracted, is used as oil cake for feeding live stock. Flax is also a valuable fibre crop. In Western Canada it is grown chiefly for seed. Nearly all of the world's flax fibre is produced in Europe.

Alfalfa or Lucerne.—This is a perennial pasture or hay crop. Its characteristics are: root—deep, spreading, tap, frequently producing rootstocks, usually bearing nodules;

stem—several branching stems spring from the crown at the head of the root; leaf—compound, three leaflets; flower—small, purple, or yellow, resembles a sweet pea, borne in clusters called racemes; seed—small, yellow, bean-shaped, produced in curled pods or legumes.

Courtesy of The Grain Growers' Guide, Ltd.
A head of rye.

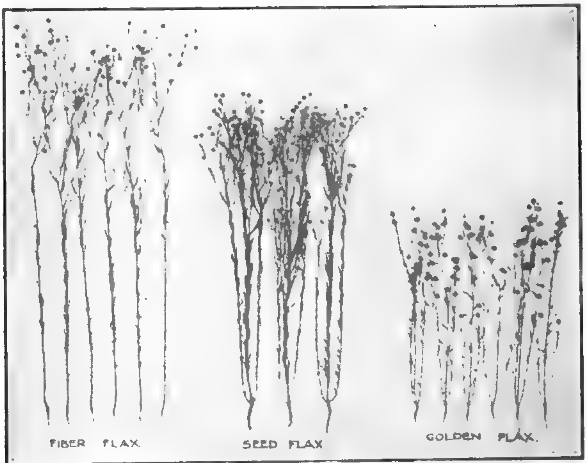
Exercises. — (1) Secure some alfalfa plants. There should be some in your locality. Failing to find any specimens, carefully uproot several pea or bean plants. Look particularly for the nodules on the roots. The most favorable time to find nodules is in the height of the growing season.

If an alfalfa plant cannot be found, a mental picture of it can be drawn as follows: root like a garden pea, bearing nodules; leaf like a clover; flower like a sweet pea but much smaller; seed like a bean but smaller and yellow. The plants mentioned all belong to the same family and in many parts closely resemble each other. Read the description of this family on page 67.

(2) Make descriptive sketches of the characteristic parts of the plant, such as the seed, flower, leaf, and root, showing particularly the nodules.

Alfalfa is a member of the Leguminosae or Legume Family, which includes peas, beans, clovers, caraganas, vetches, etc. On the roots of these plants are small,

irregular-shaped, white lumps called nodules. The nodules are the homes of bacteria that have the power to take nitrogen from the air in the soil. This nitrogen is stored up in the leaves, stems, and roots of the legume. When an alfalfa or clover plant dies, the nitrogen in its body is left in the soil, where it becomes available to plants such as



Courtesy of The Grain Growers' Guide, Ltd.

Types of flax. The fibre flax is sown thicker so that it grows with fewer branches and taller. Is there any fibre flax grown in your district?

wheat, oats, grasses, flowers, vegetables, trees, etc., which cannot use the free nitrogen of the air as the legumes do. (See pages 18 and 19.)

There are few crops more palatable and nutritious than alfalfa as hay or pasture. When it is used as roughage, less grain may be fed, thus reducing the cost of the ration. In a rotation of crops, alfalfa should follow grain or other exhaustive crops.

Alfalfa seed is sown about June 1st at the rate of 10 or 12 pounds per acre. The soil should be well prepared and free from weeds.

In order to establish the right kind of bacteria in the soil the seed should be *inoculated.* This is accomplished by securing a supply of bacteria from an Agricultural College or a seed company. The night before the seed is to be sown the contents of the bottle containing the bacteria are dissolved in milk to which a little glue has been added. The seed is thoroughly soaked in the liquid, dried, and sown the following day. Inoculation may also be accomplished

Courtesy of The Grain Growers' Guide, Ltd.

Alfalfa plants, showing how the yield is affected by cutting the crop late the previous fall as compared with cutting it early and leaving some growth for winter protection, and (on the right) yield of uninoculated and inoculated plants.

by spreading over the field soil in which alfalfa has been grown, but this requires more labor than the first method and is not as satisfactory.

Ordinarily alfalfa should not be pastured the first year, nor will it yield much hay, but in the following years yields of 1 to $2\frac{1}{2}$ tons per acre may be expected and frequently several crops a year.

The crop should be cut when about one-tenth in bloom and before the new shoots are too high. If the second growth is too far advanced, it will be damaged by the mower during the cutting of the first crop. As soon as the

plants are nicely wilted, they should be raked into small coils or piles, left loose to ensure a good circulation of air. Good judgment must be used at this time in deciding when the alfalfa is ready to store in loft or stack. If put away too damp, it will heat and spoil; but when allowed to become too dry, the leaves fall off. The leaves are the most nutritious part of the plant, and great care must be taken to save as much leaf as possible.

Exercises.—(1) Explain why alfalfa is so valuable for feeding young live stock and for dairy cows.

(2) See problems on legumes and soil fertility, pages 20 and 26.

Sweet clover.

Sweet Clover.—There are two widely used species of sweet clover —the white-flowered and the yellow-flowered. Both are biennials. Description in general: root—long, tap, bearing nodules; stems—tall, from about 2 feet the first year to 5 or 6 feet or more the second, erect, branching; leaf—compound, 3 leaflets, toothed edge; flower—small, yellow or white according to species, resembles sweet pea, borne in long, loose racemes; seed—small, yellow, hard-coated, bean-shaped, produced singly in pods.

Exercises.—Where sweet clover is grown in the district, specimens should be obtained and examined. Make sketches of characteristic parts, such as a leaf, one flower, a seed, the root showing nodules.

Sweet clover is a member of the Legume Family. Like alfalfa, it gathers free nitrogen from the air in the soil and stores it up in leaf, stem, and root. It is valuable as a hay

and pasture crop and is almost as rich in protein as alfalfa. Because it is a nitrogen-gatherer, sweet clover is useful in the rotation to restore this important plant food to the soil, when depleted by wheat or other exhaustive crop.

Sweet clover is sown on well-prepared soil, either with a cereal, or during June if grown without a "nurse" crop. From 10 to 15 pounds of seed per acre are required. The seed is protected by an exceedingly hard covering and will frequently lie in the ground for a year before germinating. In order to hasten the germination it should be *scarified.* This process consists of passing the seed through a machine that scratches or loosens the seed coat. When the seed has been scarified, a more even germination is secured. The seed should also be *inoculated* in the same way and for a similar purpose as alfalfa seed.

Sweet clover should be pastured very little the first year. The first season's growth is better left to trap the snow for protection during the winter. The second summer, however, it forms an excellent pasture. It has a peculiar, bitter flavor, and at first most animals find it unpalatable, but, once they have developed a taste for it, they will frequently pass by other feeds to reach it. Sweet clover should be kept pastured quite close, as the older plants become very woody and lose a great deal of their food value.

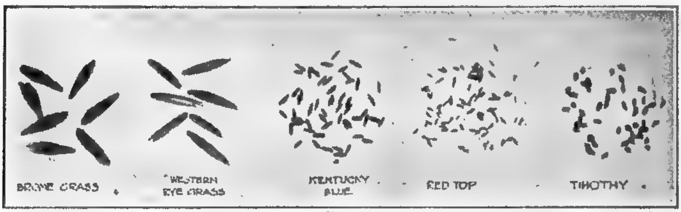
Very little hay should be cut from a field of sweet clover the first year. The second year two crops may be harvested; the first should be cut early before the blossoms develop. If left later, the stems become woody and coarse, and the second growth is likely to be damaged. It is cut with a mower and coiled. Sweet clover is very difficult to cure. The stems contain a great deal of moisture, which will cause the hay to spoil if it is not very thoroughly dried before being stored. On the other hand, like alfalfa, a great deal

of the food value of sweet clover is in the leaves, which very readily drop off when the plants are dried.

Project.—Gather and mount a collection of legumes. Show, if possible, the nodules on the roots of each specimen. (For suggestions on mounting, see page 131.)

Western Rye Grass.—This is a deep-rooted perennial. It is a native of Western Canada and can be identified by its long, slender spike or head.

It is a very hardy grass and grows well even in the drier districts. While western rye grass is splendid for general use, it is better for hay than for pasture, as it is a "bunch"



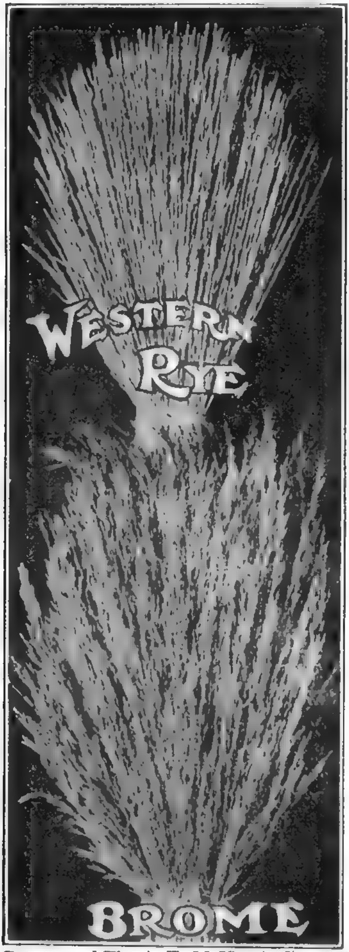
Courtesy of The Gran Growers' Guide, Ltd.

Seeds of grasses grown in Western Canada. Which two are grown most extensively ?

grass and cannot stand being tramped by the stock. Unless sown in a mixture with a grass having spreading underground stems, it is liable to leave bare spots in the field when pastured. Like all other grasses, it should follow wheat and oats in the rotation to restore fibre or humus to the soil.

Western rye grass may be sown at the rate of 12 to 14 pounds per acre, alone or with the first crop of grain after summerfallow. By the latter method the grass seed receives the advantage of the moisture stored by the summerfallow, and the grain acts as a "nurse" crop. The grain is harvested the first season, and the grass or hay the second and succeeding years. An average yield is from 1 to $1\frac{1}{2}$ tons per acre.

Western rye grass should be cut as soon as the plants commence to bloom. After this stage the hay becomes coarse and woody, losing much of its food value. Soon after it is cut the grass is raked into rows, then into small piles or cocks. There it is left until thoroughly cured or dried, when it is stacked.



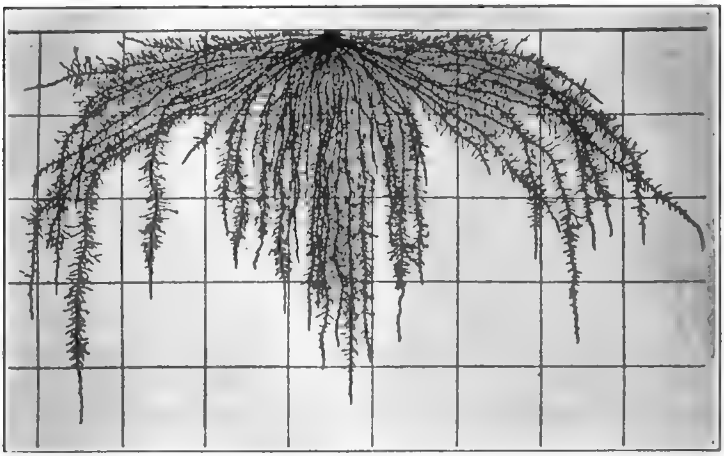
Courtesy of The A. E. McKenzie Co., Ltd.
Sheaves of the two grasses most widely grown in Western Canada.

Brome Grass.—Brome grass is more leafy than western rye grass. It can be distinguished by its loose open panicle, which develops a purplish tinge as it matures.

Brome is a hardy, drought-resistant, pasture and hay grass. It is better for pasture purposes than western rye because of its creeping underground stems. As a crop to add fibre to the soil, there are few grasses to compare with it. Brome is an excellent grass to use to crowd out weeds. The seed is sown at the same rate and in the same manner as western rye grass. It is also harvested and cured by the same methods. In heavy soils brome is sometimes hard to eradicate, but usually a double plowing will completely destroy it.

Corn.—Corn is a typical grass plant. Examine a specimen carefully to verify this statement. You will find the stem filled with pith but otherwise similar to wheat, oats, and other grasses. Observe that the roots are spread out horizontally and very near the surface of the ground. This is an important thing to remember when cultivating corn. Deep cultivation destroys many roots.

The *flowers of the corn* are different from those of any grass that we have yet examined. They are called *unisexual*



Courtesy of The Publications Branch, Regina.

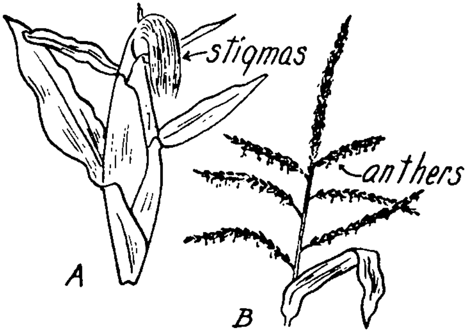
The fibrous root system of the corn. Notice the large number of roots near the surface, showing the necessity of shallower cultivation as the corn matures.

because the stamens and pistils are found in different flowers. The *staminate flowers*, having stamens but no pistils, are in the tassel. What will be the function of a staminate flower? The *pistillate flowers*, bearing pistils but no stamens, are produced in the cob. The silk of the corn is the stigma, and the kernel is the ovary. The pistillate flowers receive the pollen necessary for fertilization from the staminate flowers of the tassel. Observe the

tassel early in the summer and notice the pollen-covered stamens. Even late in the fall in the dead tassels you will readily find the dried-up stamens.

Can you name any other plants of field or garden with pistillate and staminate flowers? Why do gardeners transfer pollen from one flower to another in squash and cucumber plants?

To grow corn to full maturity requires a long, hot growing season. Consequently in Western Canada it is grown very little as a grain crop. It is used chiefly for feeding live stock and to clean and improve the soil. The thorough cultivation necessary for the production of corn destroys weeds and puts the land in such condition that wheat grown on corn land will frequently equal and sometimes produce a higher yield than when sown on summerfallow. As a substitute for summerfallow, corn cleans and improves the soil and at the same time produces a crop and prevents soil-drifting without affecting to any extent the yield of following grain crops. As a forage (feeding) crop, corn is used chiefly as a dry roughage or as silage. It is the most suitable silage crop which we have.



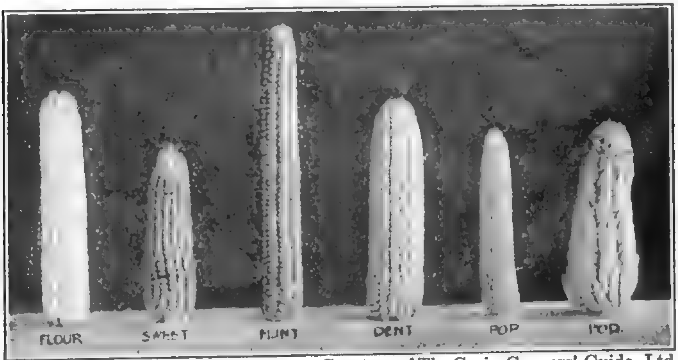
The flowers of the corn plant. A, the cob, which is a spike composed of pistillate flowers. B, the tassel, which is a group of staminate flowers. (Draw.)

The soil should be thoroughly prepared and manured at the rate of 4 to 6 tons per acre if possible. Seed must be tested for germination. It is sown, usually during the latter half of May, at the rate of 20 pounds per acre. In

Western Canada it is most commonly planted with an ordinary grain drill, in rows 3 to 4 feet apart.

The land should be harrowed once or twice to kill weeds before the plants are more than 6 inches high. From then on, the more cultivation the better, at first fairly deep but later shallow. Why?

Corn should be allowed to grow as long as possible in the fall, but care must be taken to prevent damage by frost.



Courtesy of The Grain Growers' Guide, Ltd.

Ears of different species of corn. Varieties of Flint and Dent corn are grown for feeding live stock

It is harvested, usually early in September, with a grain binder or corn harvester. If it is to be used as dry roughage, it is cured by stooking it. When stacked alone, care must be taken to have it thoroughly dried to prevent heating. Stacks are often built in alternate layers of corn and dry straw. The straw absorbs excess moisture in the corn. *The best way to store corn is as silage.* (See page 196.)

Note.—Every school should have a copy of *Fodder and Pasture Plants*, which is beautifully illustrated in colors, and is for sale by single copies at the office of the King's Printer, Government Printing Bureau, Ottawa, at $1.00.

CHAPTER VI

THE VEGETABLE GARDEN AND ORCHARD

A well-planned vegetable garden that can be cared for with a minimum amount of time and energy is a source of great satisfaction and no little profit. It can be made to supply an abundance and a variety of vegetables for the entire year. A farm orchard, also, is no longer considered a very difficult undertaking on the prairies, and many fruits can be grown with success.

The Location of the Garden.—Protection.—It is essential to protect the garden from the wind, one of the worst enemies of successful gardening, by a dense shelter belt of trees and shrubs. However, the trees should not be closer than 30 feet, because their roots rob the garden soil of moisture and plant food, and their tops shut out too much sunlight. A situation near the house, where most of the garden produce is used, is very desirable.

The Soil.—Preparation.—A deep, rich loam that has been heavily manured and thoroughly prepared will give the best results. The soil must be well drained and free from alkali. Heavy clay soils or extremely sandy soils are not desirable, but either can be made suitable, in most cases, by a heavy application of well-rotted manure. Pulverized limestone or ashes will reduce the tendency of clay soils to bake. The seeds of many garden crops are very small, and for this and other reasons a finely pulverized seed bed is necessary. State the other reasons. Plowing or spading in the fall helps to control harmful insects and in other ways is usually more satisfactory then when these operations are left until spring.

The Compost Heap.—A splendid supply of organic matter for the garden soil may be prepared by piling the waste stems and leaves of the garden and the grass mowed from the lawn in layers, 6 or 8 inches deep, alternating with 1 or 2 inches of soil. If the heap is kept moist and forked over once or twice in the fall and again early in the spring, the plant material in it will readily decay. The pile will be more likely to remain damp if the top is flat and the sides are perpendicular. In the spring the compost heap can be spread over the garden like manure and thoroughly spaded into the soil. Diseased plants or weeds bearing ripe seeds should not be thrown on the pile. Why?

Arrangement of the Crops.—The farm garden should be planned to use horse labor as much as possible. For this reason the crops should be sown in long, straight rows, if necessary planting more than one kind of crop in each row. The rows should be uniformly spaced, with the exception of those containing squash, citron, etc., or permanent crops, such as rhubarb and asparagus. This arrangement makes it possible to cultivate the garden with one adjustment in the width of the cultivator teeth. Even in city gardens long, uniformly spaced rows will be found to save a great deal of time, especially if a wheel hoe is used. Perennials, such as rhubarb, asparagus, and the small fruits, should be placed by themselves in one part of the garden. Early-maturing crops, such as lettuce and radishes, may be sown between the rows of cabbages, squash, melons, or other crops that do not mature until later in the season. Such an arrangement of early and late crops will be found to be very useful if space is limited.

Selection of the Seed.—A selection of crops should be made so that the garden will supply vegetables during the entire growing season and for winter use. Varieties that have proved to be suitable for the district should be chosen.

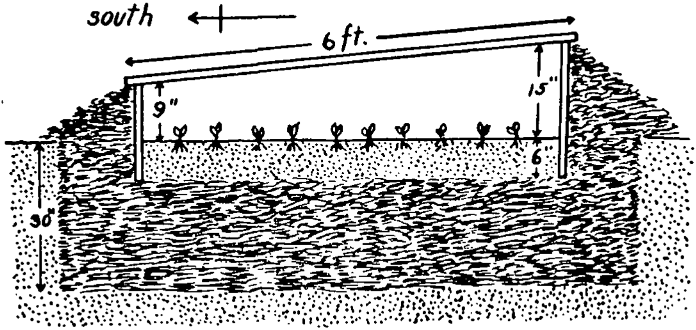
The reports of the Dominion Experimental Farms are very useful as references for suitable varieties. Copies of the report from the experimental farm nearest your locality may be obtained free by applying to the Publications Branch, Department of Agriculture, Ottawa. Western-grown seed will produce the best crops and should be ordered from seed houses in Western Canada, except where special varieties are desired.

Planting the Garden.—The garden is most easily planted with a hand or horse drill. Small seeds, such as lettuce, should not be sown over ½ to ¾ inch deep, but larger seeds like the peas and beans can be placed at a depth of 2 or 2½ inches. *It is important that the seeds touch moist soil.* Why? The soil over the seed should be tramped or packed around the seed by some other method after planting. Give two reasons. Mr. W. T. Macoun, Dominion Horticulturist, Ottawa, suggests the following planting guide:

"Varieties to be sown early in the spring: beets, carrots, lettuce, onion, parsnips, peas, radishes, kohl-rabi, garden cress, salsify, spinach, parsley, and leeks. Seeds sown in hot-beds, but plants will stand some frost: cabbage, cauliflower, and celery. Varieties to be sown after the danger of frost is over unless protected; beans, corn, cucumbers, melons, potatoes, and squash. Seed sown in hot-beds, but plants will not stand frost; melons, tomatoes, egg-plants, and peppers. Swede turnips should be sown late, though turnips will stand frost."

Hot-beds and Cold Frames.—The hot-bed should be located where it is exposed to all the sunshine possible and at the same time protected from cold winds. It may be built on top or partly below the surface of the ground. If the latter method is followed, a hole, about 18 inches deep and about 3 feet wider and longer than the frame, is prepared. Fresh heating horse manure is used as the source of heat. It should be piled near the location of the hot-bed until it starts to heat. When this occurs, the

pile should be forked over once to ensure more uniform heating. Five or six days after turning, the manure is ready for the hot-bed. From 1 to 2½ feet of it is placed in the pit. The quantity of manure required depends upon the time that the hot-bed is prepared, less being necessary for a start late in March than for an earlier beginning. The manure should be placed in the pit in layers, and each layer thoroughly tramped. The frame is then placed on the manure, and more manure is banked around the outside. A layer of about 6 inches of rich sandy soil is next thrown



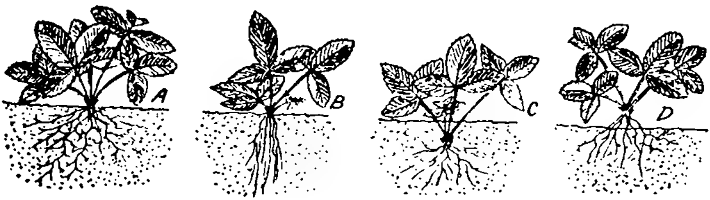
A plan of a hot-bed. (Draw.)

over the manure in the frame. After the sash is in place, it is necessary to wait for a few days before sowing seed, to allow the temperature to become regular. A temperature of from 68° to 90° Fahrenheit should be maintained by raising or lowering the sash as necessary. When the proper heat is obtained, the soil requires stirring up, and the surface should be made fine and level to receive the seeds. The essentials in the management of a hot-bed are adequate ventilation, light, moisture, heat, and protection from cold winds. Plants must be very carefully protected from chilling drafts, and should not be watered too heavily, as these conditions cause them to *damp off*. (See page 146.)

The *cold frame* is similar to a hot-bed, except that no manure is required. It is often used to receive plants transplanted from the hot-bed before it is time to put them out in the garden. Some gardeners prefer to cover their cold frames with factory cotton instead of glass.

Starting Plants In-doors.—It is possible to start a good supply of plants early by sowing the seed in shallow boxes placed in a window that has a good sunny exposure. When sufficient space is available, this method eliminates the trouble of preparing and caring for a hot-bed. Plants may also be started in-doors in this way and transplanted later to a hot-bed or cold frame. For example, tomatoes may be sown in-doors about March 1st and transplanted in early April to a hot-bed. This procedure saves a very early start with the hot-bed, and at the same time produces large hardy plants for setting out in the garden.

Transplanting.—Hardening Plants.—Most plants that have been started early in-doors or in a hot-bed are improved



The right and wrong way to set out plants. A is placed at the proper depth and with roots well spread. What is wrong with the way in which plants B, C, and D are set out?

by transplanting once or twice before they are set out in the garden. The first transplanting should take place when the plants have produced their first or second pair of permanent leaves and are about 2 inches high. They are replanted about 2 inches apart in other boxes or in another hot-bed if necessary. If they grow sufficiently to require moving again before it is time to set them out, they should be

transplanted in the same manner as before, this time leaving more space between them.

As much soil as possible must be kept around the roots when the plants are being lifted during the transplanting process. Every precaution must be exercised to prevent the roots from drying out. The roots of each plant must be spread out as much as possible. After the soil has been replaced around the roots, it should be well watered. This helps to compact the soil and work it in around the roots. The soil should not be tramped or otherwise packed while it is water-soaked. Why?

The final transplanting from hot-bed to garden is usually done about June 1st, leaving such tender plants as tomatoes until the last. It is necessary to harden the plants before removing them from the hot-bed. This is accomplished by raising the sash a little each day, gradually removing it altogether for short intervals, and then all day, finally leaving the plants entirely uncovered unless frost threatens. The newly-set-out plants should be shaded from the direct rays of the sun, and the protection of the more tender plants, particularly tomatoes, from the whipping of the wind will often prevent disappointment. For this purpose tin cans with both ends out may be used for the smaller plants. Protection to the larger plants may be provided by 3 or 4 shingles, or thin boards, such as are used in fruit crates, or boxes with the top and bottom removed. These supplies can be saved and used from year to year. An evening or a cloudy day should be chosen, if convenient, as the most suitable time for setting out plants.

Summer Use for the Hot-Bed.—After the plants have been removed to the garden, the hot-bed frame, without the sash, may be used to produce squash, tomatoes, or other crop that requires a very rich soil and a hot protected location.

Thinning.—Plants growing too close to each other become weak-rooted, tall, and spindly. To prevent this, plants that are started from seed usually require to be thinned. This must be started when they are about an inch or two high and continued regularly as growth progresses. For healthy development the leaves of one plant should just touch those of its neighbors. Frequently when carrots, beets, etc., require thinning, the young plants pulled up can be used on the table.

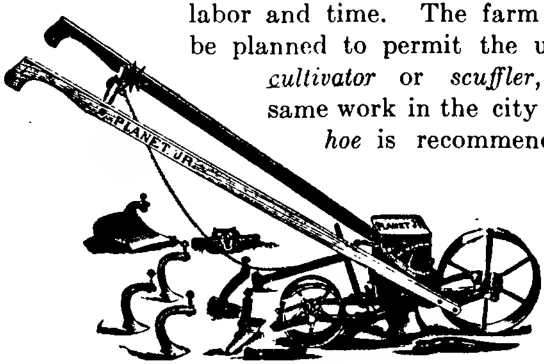
The Management of the Garden.—Crop Rotations.—The garden should be fenced. (Consult Chapters VIII, IX, and X about the control of weeds, plant diseases, and insect pests.) A clean garden, free from all unnecessary growth, will help to control insects that damage the crops. Explain how. When the garden is watered, it must be done thoroughly. Soaking a small part at a time, if necessary taking several days to cover the whole garden, is much more satisfactory than sprinkling the surface lightly every day. Once the plants are well rooted, the best results are secured by opening small trenches at intervals of from 4 to 6 feet and running water into each trench for an hour or so according to its length. After the water has been turned off and the soil around has become dry enough, the trench should be covered with dry soil. Most of the garden should be manured each year with well-rotted manure, which in most cases is best dug into the ground in the fall. Commercial fertilizers (see page 21) are usually not necessary for gardens on the prairies except in special circumstances. Frequent cultivation is required if good crops are to be produced. Why?

The most successful gardeners practise a well-planned system of *crop rotation*. Where space is available one-half of the garden plot should be summerfallowed each year, especially if the soil is heavy. Deep-rooted crops, such as

beets and carrots, should be followed by crops like peas and beans. Wide-spreading melon, squash, or cucumber vines are a change from closely planted crops. Tomatoes and corn have a different effect upon the soil from the common vegetables. A crop rotation helps to control plant diseases and injurious insects, as the pests that attack one crop do not, in most cases, damage other crops.

Exercise.—Plan a crop rotation for a medium-sized garden. Include a few permanent crops, such as rhubarb or small fruits. Submit your plan to the teacher or a gardener for approval.

Gardening Tools.—Tools must be selected that will perform the necessary work with the least expenditure of labor and time. The farm garden should be planned to permit the use of a *horse-cultivator* or *scuffler*, and for the same work in the city garden a *wheel-hoe* is recommended. A strong *spading fork*, a *steel rake*, and an ordinary *hoe* are necessary. A *Dutch* or *push hoe* is advised, as it leaves the surface of the soil smoother than the other hoe and is not as tiring to use. A trowel, a weeder, and other small tools are useful but not essential. A very convenient tool for opening the ground when transplanting small cabbages, strawberry plants, etc. is a *dibble*, which may be simply a sharpened stick or the handle of an old spade, pointed to make it easier to thrust it into the ground.



A combination seeder and wheel-hoe. The seeder attachment can be removed and the small plow or the cultivator teeth fixed in place in a few minutes.

Harvesting Vegetables.—The proper time to harvest vegetables depends chiefly upon their maturity and upon the manner in which they are to be used. Peas and beans should be gathered young and fresh for serving green, or well ripened if the seed is the product desired. Beets and carrots may be pulled and used from the time when they need thinning until they are harvested in the fall. Cabbage is ready for use as soon as a large solid head is formed.

Courtesy of The Grain Growers' Guide, Ltd.

Harvesting potatoes with a potato digger.

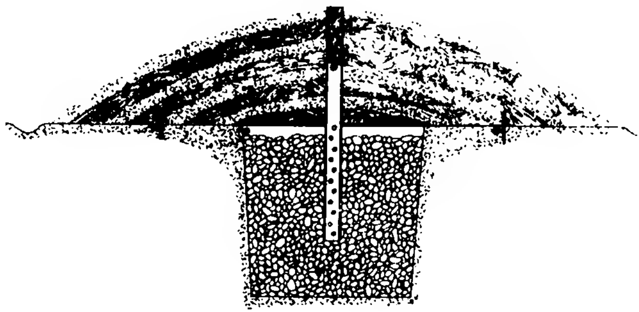
Tomatoes are picked green for pickling or left on the vines to ripen if they are for table use. Late tomatoes may be gathered green and ripened in a warm, sunny window. They may be stored in a cool, dark place and brought out to the window a few at a time as required. By this method tomatoes may be provided for the table late in the year. Onions are pulled and left on the top of the ground for a few days to dry, covering them at night for protection from frost if necessary. Mud-covered root or tuber crops are undesirable, and these crops should be harvested when the soil is dry and crumbly. It is necessary to guard tomatoes,

cucumbers, and other tender vegetables from early fall frosts. Vegetables such as cabbages, turnips, etc., will stand some frost but must not be exposed to heavy freezing.

It is not difficult to produce vegetable seed, and such efforts are quite profitable.

Project.—Write to the Publications Branch, Department of Agriculture, Ottawa, for special Circular 12 E.F., and Circular 17 E.F., being parts 1 and 2 of *Every Gardener his own Seed Grower.* Grow your own seed for next summer's garden.

Storing Vegetables.—Vegetables should be sound, dry, and clean when placed in storage. They may be kept in



Courtesy of The Grain Growers' Guide, Ltd.

An earth pit for roots or potatoes. The ventilator is plugged with straw or sacking after the real cold weather sets in.

cellars, pits, and root-houses. The essentials of any storehouse are: darkness, cool temperature, moderately moist air, ventilation, and protection from frost. If the store-room is exceedingly dry, too much moisture will evaporate from the vegetables. Poor ventilation and dampness cause decay. Onions should be placed on slatted shelves to provide a good circulation of air around them. The outside leaves should be stripped from cabbages and cauliflower, which are best stored hung by the stem-end from the ceiling. Why? Carrots, beets, and other small roots

are usually stored in sand to prevent them from becoming dry and soft. All of these vegetables should be kept at a temperature just above freezing.

Root crops and potatoes may be stored all winter in *pits*. The pit must be deep enough to have the top of its contents below the surface of the ground. After the pit is filled, a few boards or poles are laid across the top. Then four or more alternate layers of straw and soil, from 8 inches to a foot thick are placed over the boards and extended to 6 feet or more beyond the sides of the pit. This cover should be well packed against the surface of the ground around the pit to prevent the frost penetrating the space between the ground and the cover. Ventilators must be installed at intervals of about 7 feet. A *root cellar* is constructed in much the same way, but is larger and provided with bins and a permanent door.

NOTE.—Send to Ottawa for Pamphlet 10 N.S., *Root and Storage Cellars*, and Exhibition Circular 57, *Pitting Roots*.

Marketing Vegetables.—Vegetables intended for market should be clean and sound. Every precaution must be taken to prevent the spread of vegetable diseases in shipments from one part of the country to another.

Most of the vegetables grown in the Prairie Provinces are marketed at home. Potatoes are the only vegetable exported. These are sold to the United States or Eastern Canada when these places have light potato crops. Lack of facilities to store our surplus vegetables makes it necessary to import many vegetables during the winter and spring months. We buy head lettuce and cabbages from California, tomatoes from Florida, and other vegetables from the Southern and Western States.

NOTE.—Students who are interested in the grading and marketing of vegetables should write to the office of the Dominion Government

Fruit Branch at Winnipeg, Regina, Saskatoon, Calgary, or Edmonton for a copy of the *Root Vegetables Act.* This will give you reliable information about the grades of vegetables, the form and dimensions of packages, methods of packing, etc.

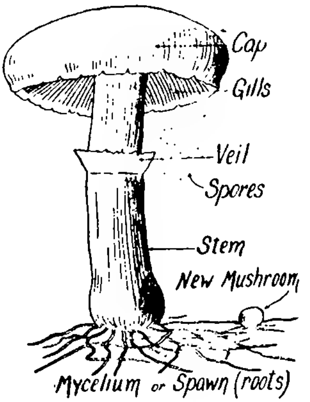
The School Garden.—NOTE TO TEACHER.—The School garden may exist in a variety of forms. It does not have to include everything or be too large. The planning, planting, and care of a windbreak is a type of school garden activity well worth while. If a shelter belt has been started but allowed to become weedy and filled up with grass, splendid work could be done in cleaning out these tree enemies and re-establishing good growing conditions for the trees. Even the planting and care of a window box or two is in a small way a form of school garden.

A large vegetable or flower garden at school should be undertaken only when the supervision of an experienced gardener is available. It is essential also to arrange for the care of the garden during the summer vacation. If these two suggestions are neglected, school gardening activities will in all probability result in failure, and have a very detrimental effect upon the students' interest in this branch of agriculture. However, properly conducted, the school garden may be made to serve several very useful purposes. It may be a miniature experimental farm, where theories discussed in class may be tried out. Small plots of the various varieties of some of the grains, grasses, or vegetable crops may be grown, and the students encouraged to prepare written reports at intervals during the growing season with the object of arriving at the comparative value of the varieties in that district. If an account of all expenditures and receipts is kept, the student will receive experience in farm bookkeeping. Various cultural practices may be tested. For example, three plots of carrots are sown. One plot is to be cultivated every week, another every two weeks, and the third every three weeks. A written record must be kept of the growth of the plants, the moist or dry condition of the soil, the growth of weeds, the final yield, etc. All other conditions, such as the quantity of seed used, the depth of seeding, thinning, etc., should be exactly the same for each plot. Another very useful purpose of the school garden is to supply material for winter lessons in nature study, botany, entomology, and agriculture.

The garden may be arranged in small plots or as one large garden in which all the students co-operate. The small plots are less desirable because they are not practical: they are neither like the garden which

the student finds at home nor the kind which he will have when he grows up.

The Growing of Mushrooms.—Mushrooms may be grown out-doors in sheltered, well-drained, shady locations from June to September and in-doors in barns, cellars, root-houses, green-houses, etc., during fall, winter, and spring. The spawn is best planted in well-prepared beds of fresh heating horse manure. The manure is piled up and thoroughly forked over three or four times at intervals of two or three days. It is then placed in the bed and firmly packed by tramping. Fresh spawn is next planted in the manure, over which is then spread a few inches of clean moist soil. The whole bed is finally covered with 8 or 10 inches of straw, which should be kept loose and moist. The spawn is a mass of mycelium or mushroom roots. These roots soon grow out in all directions through the bed, developing fruiting bodies which produce clusters of new mushrooms.



A mushroom, which is a fungus. See pages 107 and 135. (Draw.)

NOTE.—Mushroom spawn may be purchased from any reliable seed company, who, in most cases, will also forward a free pamphlet on the culture of these fungi.

Try growing a few mushrooms among the potatoes, cucumbers, squash, etc., especially if the latter are being grown in the hot-bed frame.

Bush Fruits.—Bush fruits are those of a bush-like nature, such as the gooseberries, raspberries, blackberries, loganberries, strawberries, currants, and a few other native sorts. These are all readily and profitably grown, if pro-

tected from the wind by a thick shelter belt. They are easily propagated by the following methods: gooseberries by layers, currants by stem cuttings and layers, raspberries by rooted suckers, blackberries by suckers and root cuttings, and strawberries by stolons. (See pages 106 to 109.)

The soil must be thoroughly prepared before the plants are set out. Summerfallowing is advisable. Currants are planted 5 feet apart, gooseberries 4 feet, and raspberries 3 feet apart in rows 6 feet from each other. Strawberries are arranged 18 inches apart in rows 4 feet apart. During the summer thorough cultivation, in some cases quite shallow, is necessary to encourage the greatest production of fruit. Raspberries, gooseberries, and strawberries require winter protection. Just before freeze-up, raspberry and gooseberry stems are bent down in line with the row and covered with soil until spring. Strawberries should be covered, just after freeze-up, with about 6 inches of strawy horse manure, which is left on in the spring until the season of alternate freezing and thawing is over. When this covering is removed, enough of the strawy part is left to form a mulch and keep the berries off the ground. Gooseberries, raspberries, and currants must be pruned annually to keep the stems upright, to remove old branches that have ceased bearing fruit, and to keep the cen-

Aiken plums in blossom. Fruit trees add a great deal to the attractiveness of the farmstead.

tre of the bush open to admit the light. All but six or eight strong young stems should be cut out each time. In currant and gooseberry bushes there should be no wood over three years old. A constant watch must be kept for the appearance of disease or insect pests. It is necessary to replant plantations of bush fruits at intervals, as the plants lose their vigor.

Exercise.—Write a short account of the propagation, planting, care, pruning, protection from disease and insects of raspberries, gooseberries, currants, and strawberries. Students who would like to grow a few bush fruits in their gardens should study carefully some of the government bulletins. (See page VIII.)

A red currant bush. A, before pruning. B, after pruning.

The Tree Fruits.—These require a rich, well-drained loam soil, free from alkali. A north-eastern slope is desirable. It is essential to provide an effective shelter belt and snow trap. (See page 289.) The trees are best planted from 10 to 20 feet apart in rows 16 feet or more apart and running north and south. A good plan is to alternate the rows of the various kinds, such as apples and plums. Cultivation between the rows is necessary during the growing season, and, as disease or insect pests appear, spraying will be required. (See pages 110 to 112 for notes

on the propagation of tree fruits by such methods as budding and grafting.) The native plum and sandcherry are highly recommended, as is also the Siberian crab apple. Many other varieties of tree fruits are now being grown with splendid success in the Prairie Provinces.

Pruning.—It often becomes necessary to remove or trim some of the branches of trees or shrubs for one or more of the following reasons: to improve their shape, to thin the branches and allow more light into the lower parts of the tree, to remove dead or diseased branches, to encourage fruit trees and bushes to produce more fruit-bearing branches, or to balance the top of a tree with the reduced root system during transplanting. The operation should be done when the plants are dormant, and should not be too heavy at one time. Care must be taken not to leave stubs of branches. This is prevented by cutting back to a branch or to a bud each time. Wounds, $1\frac{1}{2}$ inches in diameter and over, should be painted with a mixture of white lead and oil.

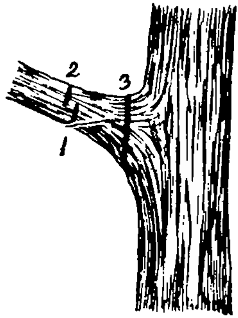


Diagram showing how to remove a large limb from a tree. Cuts should be made in the order indicated.

NOTE TO TEACHERS AND STUDENTS.—(1) Send to the Department of Agriculture, Ottawa, for Ex. Circular 17, *The Protection of Fruit Trees from Mice and Rabbits.*

(2) Lack of space prevents the mention of various fruits suitable for all parts of the Prairie Provinces. As suggested for vegetable varieties (page 92), the Dominion Experimental Farms are very reliable for information about varieties or other details of the orchard.

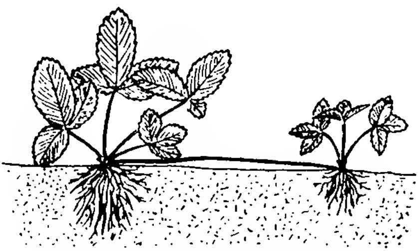
(3) Schools where there are students interested in the marketing of fruit should write to the office of the Dominion Fruit Branch at one of the cities mentioned on page 100, for a copy of the *Fruit Act.* This will contain information about the packing, the form and size of the packages, etc.

CHAPTER VII

THE PROPAGATION AND IMPROVEMENT OF PLANTS

Plants have developed many schemes by which they are propagated or reproduced *naturally*, and man has invented other methods that are more or less *artificial*.

Natural Propagation.—*Seeds* are perhaps the most common means of plant production. Many devices are employed by the plants to disperse their seeds when ripe and prevent overcrowding. *Underground stems* or *rootstocks* are found on such plants as the thistles and many of the grasses. The rootstock creeps along just below the surface of the ground and sends up new plants at the joints or nodes. Potatoes are swollen underground stems.



A runner or natural layer of the strawberry. (Draw.)

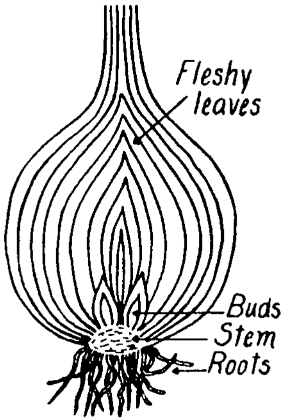
Stolons or *runners* are produced by the strawberry. The stolon is sent out by the parent plant along the surface of the ground, and takes root at the nodes, producing new plants.

Suckers are stems that spring underground from the parent plant and take root, sending up a new plant which becomes independent when the sucker is severed. Roses, red raspberries, and blackberries reproduce in this manner.

Lilies, onions, and other plants of the same family are reproduced by *bulbs*, which are modified forms of buds.

The onion is a good example. It is composed of buds, which are surrounded and protected by layers of thick, fleshy leaves, growing from a very short stem above a dense fibrous root.

Flowerless plants, such as fungi (rust, smuts, mushrooms, toadstools, etc.) and ferns, are reproduced by *spores*. If the frond (leaf) of a fern is examined, many tiny brown dots will be found. These dots are groups of *spore cases* or *sporangia*, which are filled with numerous microscopic bodies called spores. When the spores are ripe, they fall to the ground and, after undergoing a special development, produce new ferns. Spores and seeds must not be confused —they serve a similar purpose, but are different in other respects.



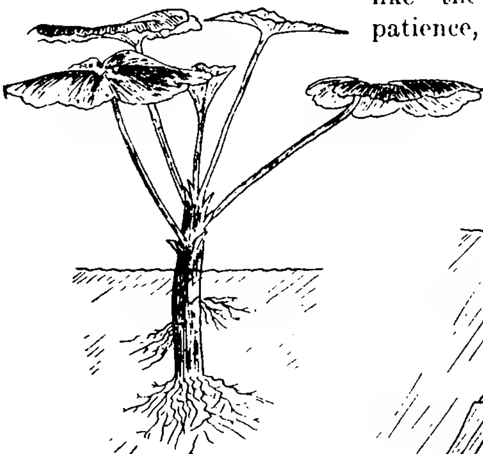
A lengthwise section of an onion, a typical bulb. (Draw.)

Exercise.—Obtain a fern frond bearing sporangia. Examine it under a good magnifying glass or low-power microscope. Scrape some off and prepare a slide. (See page 55.) Crush some of the spore cases before placing the cover-glass over them. When under the microscope, gently press on the cover-glass with the point of a knife and observe the spore cases open. Draw what you see.

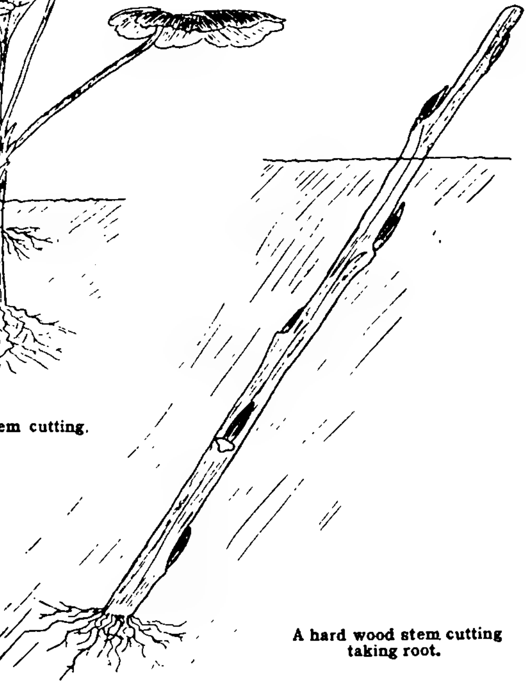
Artificial Propagation.—Some of the methods of reproduction discussed in the foregoing paragraphs are either natural or artificial, but the following very rarely occur naturally, having been developed by man to increase plant propagation.

Cuttings are parts of the roots, stems, or leaves of growing plants, from which new plants of the same kind may be developed. Blackberries may be propagated by *root cuttings*, which are made either in the fall or in the spring. The root is cut into pieces 2 or 3 inches long. If the cuttings

are made in the fall, they are stored in sand over winter. When planted in moist soil, new plants are produced. Rhubarb roots may be dug up in the spring, divided into sections, and replanted to produce new plants. Plants like the geranium, coleus, patience, etc., are propagated



A rooted soft wood stem cutting.



A hard wood stem cutting taking root.

by *slips* or *soft wood stem cuttings,* made from the younger parts of the plant. The section of the stem to go underground should have several nodes, as the new roots develop from these points. Slips may be started in water, moist sand, or clean damp soil. It is necessary to shade them from the direct rays of the sun for a few days. Plants with woody stems, such as currants, grapes,

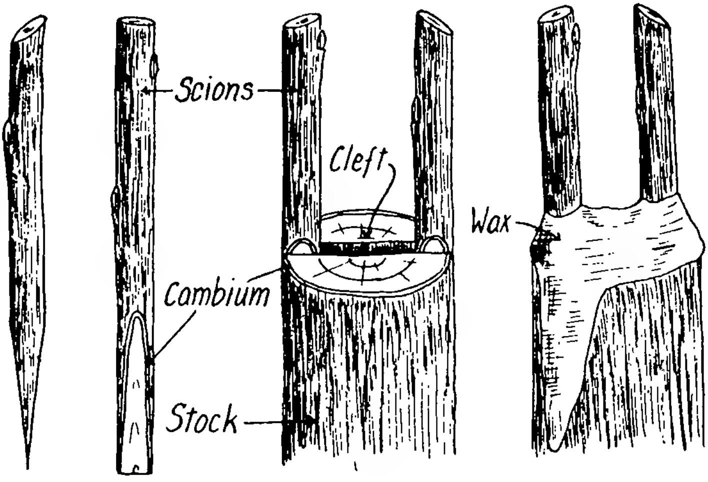
willows, and poplars, may be multiplied by ***hard wood stem cuttings***. These cuttings are prepared both in the fall and in the spring. Well-matured young branches, bearing buds, are used. They are cut into pieces 8 or 10 inches long. Frequently they are planted at once, or, when made in the fall, they may be stored for a time in sand or soil. These cuttings should be placed in the ground obliquely and quite deep, leaving only one or two buds above the soil. A good supply of moisture is essential.

Projects.—(1) *Potting a plant.*—Thoroughly wash and drain the pots. Place a few pieces of broken crockery or small stones in the bottom for drainage. Next put in enough soil just to touch the roots when the plant is held in place. Then hold the plant in the middle of the pot and pour in soil around the roots, packing the soil around the sides as it is being poured in. Keep the roots well spread out. The pot should be filled with soil to within $\frac{1}{2}$ inch of the top. Finally, water the soil freely but gently. What kind of soil would you recommend for potting plants? Give reasons for your recommendation.

(2) Start a geranium cutting in moist sand or soil. After two or three weeks dig it up and examine the parts that have been underground to determine the points at which roots developed.

Layers are really cuttings, but the branch used is allowed to remain attached to the parent plant until it has taken root. Gooseberries are propagated in this manner. The plants are pruned in the fall to encourage the production of young shoots the following spring. When these have made a good growth, the earth is heaped up around and through the bush until only the tips of the young shoots remain uncovered. The soil must be packed to retain moisture. By fall the shoots will develop roots and may be separated as independent plants for transplanting. Grapes may be propagated by covering a vine with soil at certain intervals. Roots develop at the buried points, forming new plants.

Grafting is the practice of making a branch from one tree grow on another. There are two parts to every graft: the *scion*, the branch grafted on, and the *stock*, the stem to which the scion is grafted. The scion retains the characteristics of the tree from which it was taken. It will grow and use the solutions sent up by the roots of the stock but will always produce leaves, flowers, and fruit similar to its

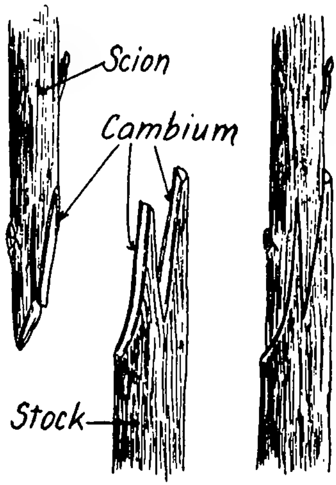


Cleft grafting. (Draw.)

parent tree. Only plants closely related may be made to grow upon each other; for example, the branch of one kind of apple may be successfully grafted to another kind of apple tree but not to a peach or other species of tree. Grafting is practised for special purposes with fruit trees, such as apples, pears, oranges, lemons, peaches, and plums. Some varieties of these fruits do not reproduce their good qualities when grown from seed. A number of trees are, therefore, started from seed, and, when they have become well established, branches from a tree with desirable characteristics

are grafted on them. The production of fruit may be hastened several years in young trees by grafting on them branches from mature trees. Frequently, when mice or rabbits have girded a tree, its life may be saved by bridging across the wounded part with five or six scions.

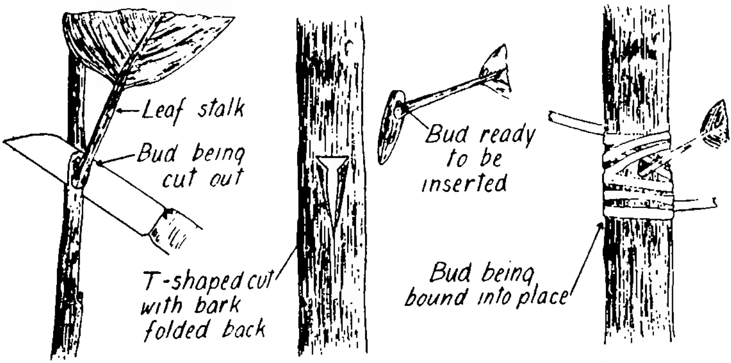
There are two common methods of grafting. The *cleft* graft is practised when two or more scions are to be grafted on one stock, which is larger than the scions. A new top may be put on a tree by this method. The top of the stock is cut off straight across, and the stock is then split lengthwise for a short distance. The scions are cut wedge-shape and fitted securely into the cleft or split in the stock. Great care must be taken to make certain that the *cambium layers* (see page 58) of the two parts of the graft are in contact. They will not grow together otherwise. Why? As soon as the scions are in place, all exposed surfaces should be thoroughly covered with *grafting wax* to prevent the escape of the sap and the entrance of disease spores. Grafting wax is a preparation consisting of 4 parts of resin, 2 parts of beeswax, and 1 part of tallow. Describe the source and nature of these materials and explain why the mixture is particularly suitable for grafting purposes. The *whip and tongue graft* is used when the scion and stock are the same size. The top of the stock is removed with a long, slanting cut, and the lower part is then split back, making a tongue. The scion is cut in the same manner.



Whip grafting. (Draw.)

The two parts are then fitted tightly together and bound with waxed strips of cloth, cord, or paper.

Grafting is usually done early in the spring, before the sap starts to flow. The best scions are mature branches of the previous season's growth and should bear several buds. They may be cut in the fall after the leaves have fallen or in the spring just before the grafting takes place. When cut in the fall, the scions are packed in sand during the winter, and kept cool and moist until they are required.



Steps in budding. (Draw.)

Budding is a modification of grafting and is used with peaches, cherries, plums, and apricots, or trees too small for grafting. A single bud is removed from one tree and made to grow beneath the bark of another. In cutting out the bud, care must be taken to remove the bud and the cambium layer behind it without any wood. The leaf stalk, which springs from just below the bud, is usually left in place to serve as a handle and to indicate whether the bud lives. A T-shaped cut is made in the bark of the stock. The flaps of bark are loosened and bent slightly back. The bud is then inserted and tied into place. It is essential to get the cambiums of the two parts together.

Why? If in the fall the leaf stalk falls off, as it should do naturally, the bud is growing; but if the stalk dries up and remains attached, the budding operation has failed. After the bud has begun to grow, the top of the stock should be cut off so that all of its energy is put into the development of the bud. Budding is done when the trees are growing most vigorously, which in this country is usually in August. It has several advantages over grafting: it may be done in less time, and, because several buds may be cut from a branch which would be suitable for but one scion, it is cheaper.

The Improvement of Plants. — Most of our cultivated crops have been developed from plants that originally grew wild in some part of the world. Wild wheat is still to be found in Palestine. During the thousands of years that these plants have been under the care of man, they have been very greatly improved; but, unless constant effort is made to retain this improvement, they tend to revert to the original wild forms and thus lose the good qualities which man has produced in them. In spite of all that has already been accomplished, there is still much that has to be done to make our crops easier to grow and more profitable to the farmer.

Variations.—Mutations.—Variations and mutations are the basis of all improvement in either plants or animals.

No two living things are exactly alike in every respect. Compare your hands with those of a classmate, or compare two leaves, flowers, etc., of the same species. A *variation* is the difference between plants or animals of the same kind. The difference between two elm leaves is a variation, but not the difference between an elm and a maple leaf. Variations may arise from two causes. The soil, climate, and other factors in the *environment* of plants will produce differences in them. Plants that are not fitted to survive

in their surroundings will attempt to develop variations in structure and methods of living, and thus adapt themselves to the conditions around them. It is surprising how quickly plants will change their habits of growth to meet new conditions. State several examples. Variations due to environment are not considered to be permanent, that is, they are not transmitted to offspring. *Cross-pollination* brings about the union of the characteristics of two plants into one plant and results in variations which are permanent and inherited.

Mutations are sudden distinct changes or variations which sometimes appear unexpectedly in a plant or an animal. The plant or animal upon which the mutation occurs is called a *mutant.* For example, a very leafy plant grows from seed produced by a plant that is not leafy and whose ancestors were not leafy. The plant would be a mutant and the leafy characteristic a mutation. Mutations are important factors in the improvement of our crops and live stock because they are inherited, that is, they are transmitted by the mutant to its offspring.

By taking advantage of superior variations, man is able to develop plants and animals more suitable for his purposes.

Heredity.—If the characters of a plant are fixed or permanent, they will be inherited by the offspring of the plant and again transmitted by the offspring to their descendants. Temporary characters are not inherited. (See page 218.)

Crossing.—Crossing is brought about by cross-pollination between two plants more or less closely related. The offspring are called *crosses.* The objects of crossing are to combine the characteristics of two or more plants in one (the offspring) and, if possible, retain the good qualities and eliminate the undesirable characters of the parents. When two plants are crossed, their characteristics, both

good and poor are transmitted to the offspring, and it requires a great deal of work and skill on the part of the plant breeder to detect plants among the offspring that possess the good qualities of the parents.

The first step in crossing is to select carefully the two plants to be used. The stamens from some of the flowers of one plant are then carefully removed to prevent self-pollination. This step is called *emasculation* and must be done before the stamens have produced pollen. By means of a small brush, pollen from the flowers of the second plant is then dusted over the stigmas of the flowers of the first plant. To prevent the flowers which have been crossed from receiving pollen from any other source, they are covered by a paper bag until seed has been formed.

Courtesy of The Grain Growers' Guide, Ltd.

Progressive steps in the crossing of wheat. A, the wheat spike just after heading; B, the upper and lower spikelets removed; C, the head wrapped to protect it from the pollen from other wheat flowers; D, the wrapping removed after fertilization.

How Marquis Wheat was Produced.—Marquis is a splendid example of cross-bred wheat. It was developed at the Ottawa Experimental Farm by Dr. C. E. Saunders. Red Fife wheat was used as the male parent and Hard Red Calcutta as the female. The former is an excellent bread-making wheat, and the latter is early maturing and

does not shatter as readily as the Red Fife. From the crosses produced Dr. Saunders discovered and selected desirable plants. He planted the seed from these and again made selections from among their offspring. After many years of painstaking work, he finally produced a new variety which he called Marquis. This wheat possesses the bread-making qualities of the Red Fife, ripens about a week earlier, and does not shatter as readily.

Selection.—New varieties have been created, and a great deal has been accomplished to improve existing varieties of crops by the careful selection of good seeds and plants. Selection means the choice of the best for use in producing more good plants, the poor being discarded. When man selects plants for such qualities as high yield, resistance to disease and drought, early maturity, etc., better crops are produced from the seed of these plants than if they had not been selected. Nature also practises a rigid scheme of *natural selection.* Plants that are not fitted to live in their surroundings die. Nature chooses only the strong and the fit to live and become the ancestors of succeeding generations. Is there any relation between this statement and the discussion of variations produced by environment (page 113)?

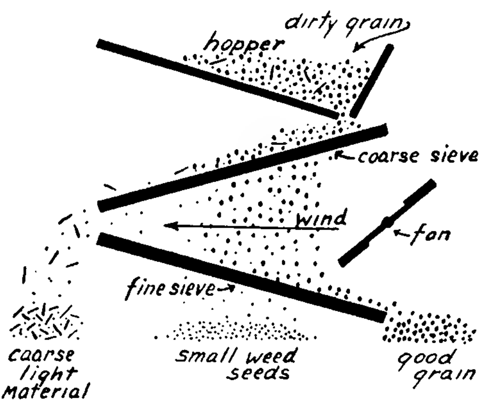


Diagram illustrating the operation of a fanning mill. Study carefully and explain how weed seeds, cracked small light shrunken wheat, bunt balls, and other grains are removed from a sample of wheat. (Draw.)

Seed Selection.—There are two methods of selecting seed. It may be done *mechanically* by the use of a fanning mill or *by hand.*

Exercise.—Obtain about 2 quarts of wheat of medium quality. Carefully work over it, selecting and separating the large, plump, bright-colored kernels from the balance of the grain. When you have two piles, weigh an equal volume from each. Account for any difference in weight. Thoroughly mix each pile, remove a representative sample and make a germination test. Estimate how much you have improved the germinating power of the wheat by removing the poor seeds, etc., from it. Would the yield and quality of the crop be improved? Give reasons.

Good seed is: large, plump, uniform in size; clean, that is free from weed seeds, straw, or other foreign material; bright and deep in color, not bleached or weathered; free from traces of disease or damage by insects; true to type and variety: for example, a sample of Marquis wheat should look like Marquis in every respect; well ripened; of strong germinating power (if there is any doubt about the vitality of the seed, it should be tested).

Germination Test.—**Exercise.**—Obtain samples of grain, grass, and vegetable seeds. In each case thoroughly mix the samples to be tested. Why? Count out 100 seeds. Place them between sheets of moist blotting paper on trays or plates. Keep the blotting paper damp. Place the seeds where the temperature will be about 68° F. After three or four days count and remove seeds that have germinated both root and stem. Keep an accurate record of all seeds counted. Continue to count and remove sprouted seeds every second day for about two weeks. Since 100 seeds were used, the total number of sprouted seeds will be the percentage of the entire sample that will germinate. If blotting paper is not available, cloth may be used, or the test may be performed by planting the seeds in shallow boxes of soil, sand, or sawdust.

Project.—Arrange with farmers to send in seed to be tested. Point out that the samples must be representative. Carefully test the seed received and report results to the farmer.

The Advantages of Good Seed.—Long, careful experimenting has proved that the best seed will, year after year, produce the best crops. Every farmer should save his choicest seed for planting. Good seed helps the crop to an earlier start, so that it is not crowded out by early weeds and is ripe in the fall before the seasons of rust and frost. When the seed is clean, it runs through the drill better, and there are fewer weeds or other grains to waste food and moisture and produce a dirty crop subject to heavy dockage. Good seed will germinate more evenly, and, other conditions being equal, the crop will be more uniform and higher in quality.

Individual Plant Selection.—In this method of improving crops a single plant, displaying the desired qualities, is selected. Seed from this plant is sown the following year, and from the crop produced selections are again made. Finally, when it is evident that the good characters of the parent plant are fixed and will be transmitted from one generation to the next, the supply of seed is multiplied to produce sufficient for general sowing.

Mass Selection of Wheat Heads.—The procedure followed in this method is to select by hand from the general crop heads of wheat which are true to type and variety, free from disease, filled at the top and bottom and otherwise superior. Usually from 20 to 40 pounds of heads are picked. This amount when threshed will sow ¼ acre. The seed is sown the following spring on clean land, free from volunteer grains. During the summer the plot must be *rogued* at intervals. To do this the grower walks through the plot and pulls up all plants that appear to be diseased, off type, or of other varieties or kinds of grain. By continuous hand selection it is possible to keep the crop pure as to variety and, to some extent, to improve its quality and yield. Every precaution must be observed at all

times to prevent the seed being mixed with other grain. Hand selection may be used to improve other crops by carefully selecting pods, panicles, ears, tubers, etc., from sound, vigorous, normally developed plants in the general crop.

Registered Pedigreed Seed.—The production of registered seed begins with a plot of *Elite stock seed,* which is the name given to the crop from a hand-selected seed plot or from a seed plot that was sown with seed originating from a single plant. Elite stock seed produces *first generation* registered seed, which in turn produces *second generation* seed. Second generation seed produces *third generation* seed, and so on.

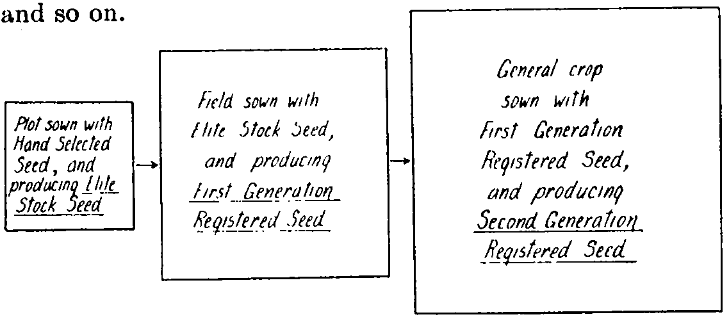


Diagram illustrating the method followed by members of the Canadian Seed Growers' Association in producing registered seed. (Draw.)

Project.—Write to the Canadian Seed Growers' Association, Ottawa, for information about the growing of registered seed. It is not necessary to produce your own Elite stock seed. You may make a start by purchasing Elite stock or first generation seed from an Agricultural College or other grower. By beginning at this point any boy or girl can make a success of growing registered seed. It has been demonstrated that registered seed returns greater profits than other seed.

The Production of New Varieties by Selection.—Dr. Seager Wheeler, while working among the seed plots on his farm at Rosthern, Saskatchewan, discovered Red Bobs, which is a selection from an Australian wheat called Bobs.

Kitchener is another variety of wheat originated by Dr. Wheeler. It was developed from a single plant selected in a field of Marquis.

The Importation of New Varieties.—The crops which are being grown in a country may sometimes be improved by importing better varieties from some other part of the world. The new plants may be used for general production or for crossing purposes.

Cultural Methods of Improving Plants.—If a farmer carefully prepares a good seed bed, sows the best seed at the proper depth and during the right season, and by every other means gives the crop the best chance to develop, he can do a very great deal to produce better crops. Improvement secured in this way is not permanent and is lost as soon as the best methods are departed from, but it is important nevertheless.

The Possibilities of Plant Improvement.—The work involved in the improvement of plants is often slow and tedious, but there are great possibilities in it. Some day a single plant may appear that is immune to rust or superior in other respects. The person who is able to recognize the good qualities of this plant, and to multiply it, will be in a position to render invaluable service to the agricultural industry of Canada. Or it may be by cross-breeding that new and superior varieties of crops will be produced. These things have been done in the past, and there is every possibility that they may be repeated, with even better results, in the future. While wheat has been the chief crop discussed in the preceding paragraphs, the principles that have been dealt with apply equally well to the improvement of all crops of the field, garden, or orchard.

Project.—Study the work of prominent plant breeders. Read about Dr. Saunders in Buller's *Essays on Wheat*, about Dr. Wheeler in his book *Profitable Grain Growing*, published by *The Grain Growers'*

Guide, Winnipeg, and about Luther Burbank in his book *Plant Breeding*, Vol. I of his series, published by P. F. Collier and Sons, New York. Clip from newspapers and magazines accounts of men in Western Canada who are doing outstanding work in the improvement of our crops, and paste them in a note-book.

Experimental Farms.– Experimental farms have been established in all parts of Canada. Those maintained by

Experimental plots at the Dominion Experimental Farm, Indian Head, Saskatchewan.

the Provincial Governments are situated at the Agricultural Colleges. See page 1 of the bulletin *Seasonable Hints* for the location of the Dominion Government Experimental Farms and Stations. The experimental farms are divided into groups of plots, which are from $\frac{1}{40}$ acre to several acres in size. The plots are used to conduct experiments in the best methods of growing crops, and to produce or test new varieties. By this means much valuable information is collected and distributed free to farmers in all parts of the Dominion. If possible, arrange to visit the experimental farm nearest your district.

CHAPTER VIII

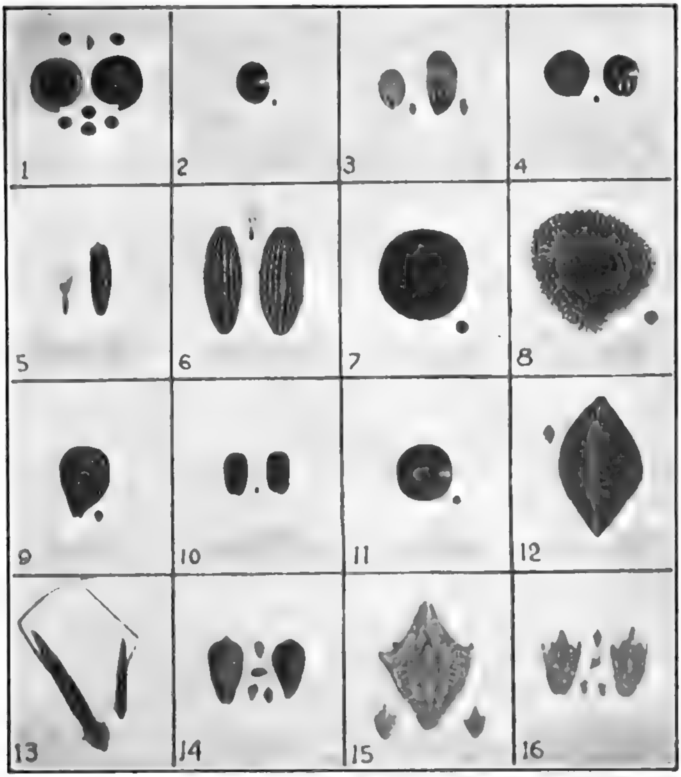
WEEDS—THEIR IDENTIFICATION AND CONTROL

A weed has been defined as a plant growing in the wrong place. A *noxious weed* is one that is especially injurious or difficult to eradicate, and for these reasons named in the Noxious Weed Act.

Classes of Weeds.—Weeds are classified according to the length of time that they live. *Annuals* are weeds which complete their growth in one year. *Biennials* live for two years, producing seed the second year. *Perennials* continue to grow for many years. *Winter annuals* are annual weeds, but their seeds begin to grow in the fall, usually forming a small flat rosette; the young plants live through the winter and start to grow rapidly very early in the spring.

Damage Done by Weeds.—Weeds reduce the yield of field and garden crops by robbing the soil of moisture and plant food, and by crowding out or shading less hardy, slower-growing plants. They are injurious to the quality of farm produce: weed seeds lower the grade and increase the dockage in grain crops; Frenchweed taints the flavor of dairy products; burrs reduce the quality of wool; and cockle seeds in wheat impart a bad taste to flour. Noxious weeds are expensive to eradicate. They provide egg-laying places for injurious insects and are "host" plants of harmful plant diseases. When a farm becomes infested with weeds, its value is very greatly reduced.

How Weeds are Spread.—Weeds are dispersed by many natural devices and, too often, by carelessness on the part



Courtesy of The Grain Growers' Guide, Ltd.

Weed seeds commonly found in Western grain.

1. Russian thistle.
2. Red-root pigweed.
3. Russian pigweed.
4. Lamb's quarters.
5. Canada thistle
6. Perennial sowthistle.
7. Cow cockle.
8. Purple cockle.
9. Frenchweed.
10. Tumbling mustard.
11. Wild mustard.
12. Wild buckwheat.
13. Wild oats.
14. Poverty-weed.
15. Tall ragweed.
16. Common ragweed.

Notice that the seeds are illustrated natural size as well as enlarged.

of the farmers themselves. They are spread: (*a*) by *wind* --tufted seeds such as dandelion and thistles, tumble weeds such as Russian thistle and tumbling mustard; (*b*) by *water*

—most seeds are oily enough to float; (*c*) by *animals*—in mud on the animals' feet or in burrs clinging to animals; also, many seeds are not digested and are spread in manure; and (*d*) by *man*—in grain, grass and legume seed, by railways, by machinery such as stook wagons, threshing machines, etc., and in the straw packing of settlers' effects.

Many of our worst weeds are of foreign origin and have been introduced into Canada by the importation of dirty seed or by immigrants when they have used weedy straw for packing.

Courtesy of Seed Branch, Ottawa.
Frenchweed or stinkweed.

The Identification of Weeds.—A very good method to use, in becoming familiar with the weeds, is to learn their general characteristics by families. The members of each plant family have many distinguishing marks in common; and, once the identity of an unknown weed has been traced to the proper family, complete identification is comparatively easy. It is also suggested that written descriptions should be very brief, and that a definite procedure be followed in tabulating observations. The proposed outline is used below in describing Frenchweed.

Name—*Frenchweed* or Stinkweed.
Family—Mustard.
Growth—annual or winter annual, reproduced by seeds.
Root—fibrous.
Stem—erect, smooth, branching, 2 to 24 inches high.
Leaf—wavy edge, upper leaves stalkless and clasp stem with arrow-shaped base, lower leaves have stalk.
Inflorescence—a raceme, indefinite, that is, the plant blooms and produces seed from early spring to late fall.

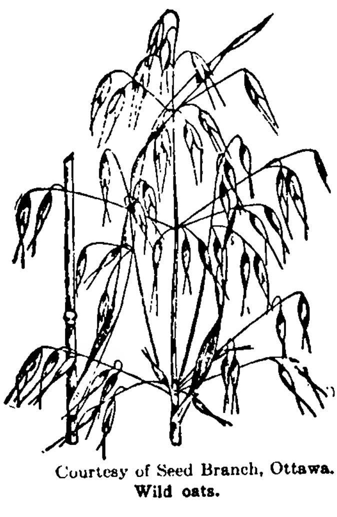
Flower—small, white, 4 petals or cross-shaped.

Seed—small, folded, purple with a metallic sheen, ringed, borne in pods that are winged with a notch at the top.

Courtesy of Seed Branch, Ottawa
Wild mustard.

Wild Mustard.—Mustard family; annual, propagated by seed; root—fibrous; stem—erect, branching, with stiff hairs pointing downward, purple at the junction of leaves and branches; leaves—deeply toothed; inflorescence—raceme; flower—bright yellow, showy, 4 petals; seeds—small, round, reddish brown, pitted, borne in long knotty pods having short spike at top.

Wild Oats.—Grass family; annual, reproduced by seeds; root, stem, leaf, and inflorescence closely resemble cultivated oats; seeds—more slender than cultivated oats, white, black, grey, brown, horse-shoe-shaped mouth at base which is surrounded by stiff bristles, a twisted awn bent at right angles.



Courtesy of Seed Branch, Ottawa.
Wild oats.

Russian Thistle.—Pigweed family, not a thistle; annual, reproduced by seed; root—small, tap, easily broken off in the fall; stem—branching, dark green when young, striped with red as matures; leaf — long, needle-shaped, pointed, drops off soon after seed is produced; inflorescence—flowers borne singly in the axils of the leaves; flower—small, greenish, inconspicuous; seed — small, 50,000 per plant, olive green, conical, coiled like a snail shell, papery covering; in the fall the plant curls up, breaks from the root, and may be blown for miles, scattering seed.

Courtesy of Seed Branch, Ottawa.
Russian thistle, not a thistle but a pigweed.

Perennial Sowthistle. — Daisy family; perennial, reproduced by seed and deep-running rootstocks, rootstocks have been found with 6 plants on a 2-inch length, others have measured 18 feet long; stem—1 to 5 feet tall, hollow, filled with bitter milky juice, few leaves, branching at top; leaf—long, deeply cut with points turning slightly backwards, filled with bitter milky juice, clasps stem with arrow-shaped base; inflorescence — dozen or more flowers in groups; flower—large, bright yellow, composite, that is, composed of small flowers called florets; seed—small, slightly bent, dark reddish brown, deeply ribbed lengthwise and cross wrinkled, topped by fine, silky, spreading hairs, which act as an efficient parachute to carry seed long distances.

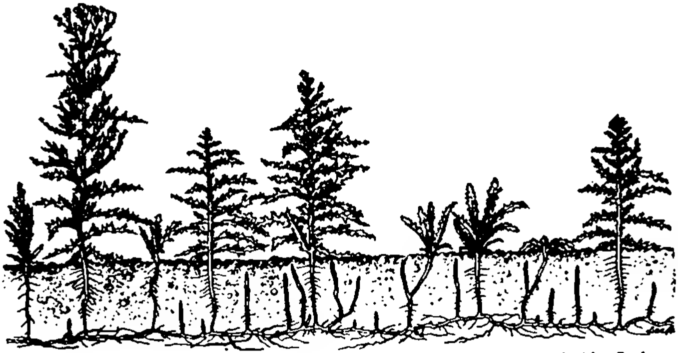
Canada Thistle. — Daisy family; perennial, reproduced by seeds and deep-running rootstocks; stem—erect, 2 to 4 feet high; leaf — narrow, twisted, sharp spines; inflorescence—dozen flowers or more in groups; flower—white, pink, or purple, compound or composite, staminate and pistillate flowers on different plants, staminate flowers spherical, pistillate oblong; seed—small, light brown, slightly bent, flattened, angular, collar at top bearing fine silky parachute.

Courtesy of Seed Branch, Ottawa.
Perennial or field sowthistle.

MS

Green Tansy Mustard.—Mustard family; biennial, reproduced by seeds; root—small, tap; stem—erect, 3 to 4 feet tall, much branched; leaf—very finely divided, very bright green; inflorescence — raceme; flower — small,

yellow, 4 petals; seed—small, reddish brown, folded, flat, covered with extremely small hairs, produced in short, slightly curved pods, which are very numerous. This weed closely resembles grey tansy mustard.



Courtesy of The Grain Growers' Guide, Ltd.
Canada thistle, showing the production of new plants from underground stems or rootstocks.

Eradication of Weeds.—Each class of weeds must be attacked in a very different manner. Methods that destroy certain weeds encourage the growth of others. In each case it is also necessary to remember that we start with infested fields and must make our objective the removal of the weeds present.

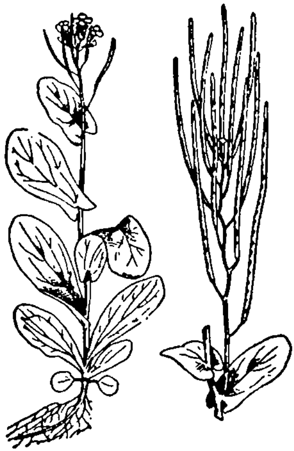
Courtesy of Seed Branch, Ottawa.
Green tansy mustard.

Annuals.—Annuals are one-year weeds. The more the plant itself grows, the nearer it approaches the time when natural causes will remove it from the field. It is the seeds that are troublesome, because they have often been known to lie in the ground for many years. As long as there are seeds in the soil,

weeds may appear at any time and crowd out and destroy young grain or grass crops. It is, therefore, the seeds of annual weeds against which the attack must be directed.

Courtesy of Seed Branch, Ottawa.
Tumbling mustard, a bad tumble weed.

The land should be cultivated quite shallow as soon as the crop is off the field in the fall to germinate seeds that are in the soil. Plants thus produced will be killed by the frost. In the spring further cultivation must be given to the soil to germinate more seeds. If the weeds are bad, the land must be summerfallowed. Cultivation is required at intervals to germinate seeds and destroy plants started by the previous cultivation. The duck-foot cultivator is the most effective implement for this purpose. When weeds like Russian thistle are present, the crop may be lightly harrowed when 5 or 6 inches high. This operation does not injure the crop and is effective in destroying the weeds. For wild oats, which ripen and shell out very early in the season, early-maturing crops are useful. When oats to be used for green feed, fall rye, or an early variety of barley are sown in an infested field, the crop will be



Courtesy of Seed Branch, Ottawa.
Hare's ear mustard.

ripe and ready to cut early enough to catch the seeds before they scatter. Weeds that have gone to seed should be mowed and, when dry, raked into piles and burned. It is much more effective, however, to prevent most weeds from seeding.

Winter annuals and biennials.—These may be eradicated by much the same methods as annuals. It would be necessary, however, to follow the early fall cultivation by another just before freeze-up to destroy young plants that would otherwise winter through. Harrowing the growing crop is also a common and effective measure to destroy young Frenchweed and similar winter annuals. In summerfallowing to kill Frenchweed, care must be taken not to give the plants time to produce seed between the intervals of cultivation. Why?


Courtesy of Seed Branch, Ottawa.
Red-root pigweed.

Perennials.—Perennials must be attacked by methods entirely different from those outlined for other weeds. It is with the plant itself that we must be concerned. The more it grows, the stronger it becomes.

The attack should begin in the fall by plowing deep enough to upturn and expose the rootstocks to the drying influence of the sun and wind and to the frost. In the spring further cultivation is necessary for the same purpose as the fall plowing. A thorough summerfallow is required when the weeds are bad. The soil must be kept black by frequent cultivation. If the development of leaves is prevented, the plants become weakened and finally die.

Explain. When the duck-foot cultivator is used, the rootstocks are dragged to the surface of the ground. The summerfallow may be pastured during the early part of the summer. Sheep readily eat sowthistle and, being very close nibblers, are effective in preventing the formation of leaves. Inter-tilled crops, such as corn, roots, etc., may be used but must be kept well cultivated. Small patches should be hoed or dug up as soon as discovered. Fuel oil or used cylinder oil, applied to the soil at the rate of 1 to 2 gallons per square yard, will kill and prevent the growth of perennial sowthistle. Small patches of this troublesome weed may be destroyed by carefully levelling the infested area, covering with tar paper, placing a layer of sod and soil over the tar paper, and leaving the whole cover in place for two years.

Courtesy of Seed Branch, Ottawa.
Great ragweed.

Exercises.—(1) Give as many examples as you can of annual, winter annual, biennial, and perennial weeds.

(2) Outline step by step the procedure to be followed in the eradication of a winter annual weed.

(3) Do you consider the fanning mill to be useful in the control of weeds? Give a reason for your answer.

(4) Make a complete summary of all the methods that are used to eradicate and control weeds. In each case state the class and give several examples of weeds against which the methods that you give are effective.

(5) Examine as many of the noxious weeds in your district as you have time for. Write a description of each as suggested for Frenchweed. Make descriptive drawings of characteristic parts.

(6) Continue your study of weeds outside of the class-room. Try to recognize the weeds which you have studied when you see them in the fields or along the roadside.

(7) Send for the weed bulletins published by the Department of Agriculture in your province.

(8) Every school should have a copy of *Weeds and Weed Seeds*, Bulletin No. 4, N.S., distributed free by the Department of Agriculture. Ottawa, and of the book *Farm Weeds in Canada*, for sale by single copies at the Office of the King's Printer, Government Printing Bureau, Ottawa, at $2.00. The latter is beautifully illustrated in colors.

(9) Barberry (with the exception of the Japanese) has now been added to the list of noxious weeds. Why has this been done?

Projects.—(1) Prepare a mount collection of noxious weeds common to your district. For this purpose secure two boards, large enough to cover the plants. Fasten them together at one end by means of straps. Select perfect and representative specimens of weeds, including the roots. Allow to wilt slightly, then spread flat on a sheet of blotting paper or five or six sheets of newspaper or wrapping paper. Arrange all parts of the plant in the natural position. Cover with paper and press between the boards. Pressure should not be heavy enough to crush or bruise the stems. Once a day remove the covers for a few minutes to air the plants and prevent them from becoming moldy or discolored. Rearrange any parts which seem to be out of place. Leave the plants in the press until they are thoroughly stiff and dry. Mount on stiff cardboard by means of thin strips of adhesive tape or paper.

(2) Make a collection of weed seeds. Place the seeds in small bottles and mount the bottles on cardboard.

CHAPTER IX

PLANT DISEASES—BACTERIA—FUNGI

Each year, crops of all kinds are very seriously damaged by plant diseases. In Canada the annual loss due to grain diseases alone amounts to from $90,000,000 to $100,000,000. It is exceedingly important that every farmer and gardener should know the cause, appearance, and life history of the diseases that may destroy his grain, vegetable, or fruit crops. He must be familiar with the most effective and cheapest methods of prevention and control.

The Cause of Plant Diseases.—Wounds, drought, poor soil, or other unfavorable conditions that tend to weaken the plant and reduce its power of resistance will make it easier for disease to establish itself in that plant. These factors are directly responsible for some diseases, but many plant diseases are caused by low forms of plant life called *bacteria* and *fungi*. These plants are dependent, that is, they have no chlorophyll and are unable to manufacture food for themselves as other plants do. Their sustenance is secured from the *host plants* upon which they live. Some of them prey upon living plants and are, therefore, called *parasites*. The rusts and smuts of grains are examples of these. Others, known as *saprophytes*, grow upon dead plant material, for instance, the rot fungi that cause wood to decay. Disease may be defined as a condition that prevents the normal body functions of a plant (or an animal) from taking place.

Bacteria.—**Exercise.**—Pack a little hay in the bottom of three test-tubes. Fill each tube about three-quarters full of water. Tightly plug one tube, as it is, with absorbent cotton. To the water in a

second tube add a small amount of formalin (formaldehyde) and plug. The third tube is to be plugged, then steamed for 30 minutes. Steaming may be done by putting about an inch of water in a glass vessel and heating it by means of an alcohol lamp or Bunsen burner. Be sure to have a wire screen between the flame and the glass to avoid breaking the glass. A pan on the stove would do equally as well. Place the test-tube upright in the steamer and cover loosely. A label, stating clearly what has been done, should be stuck to each test-tube. Put all three tubes in a warm place. After several days examine each tube carefully, noting any changes that have occurred in the water in the interval.

Bacteria magnified over 1000 times. (Draw.)

In a few days a scum will form on the top of the water in the first test-tube. If a speck of this scum is examined under a powerful microscope, numbers of minute one-celled bodies may be seen. These are *bacteria* (sing. *bacterium*). They were discovered in 1695 by Leuwenhoek, when he invented a microscope powerful enough to see them. Being about $\frac{1}{50,000}$ inch in diameter, it is necessary to magnify them about a thousand times before they become visible. The student who has not a microscope with an oil immersion lens will not be able to see bacteria but will have to be content with watching their behavior in colonies or masses.

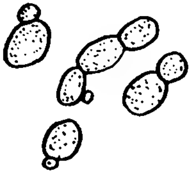
Exercises.—(1) Why did no bacteria develop in the second and third test-tubes?

(2) Where did they come from in the first?

(3) Bacteria reproduce by division. The bacterium first grows longer. Then a partition forms across it. Finally it separates into two new bacteria. The process occupies about half an hour. Calculate the number that might be produced from one bacterium in half a day.

Yeasts.—**Exercise.**—Dissolve 2 teaspoonfuls of brown sugar or molasses in a cup of water. Add about half a compressed yeast cake. Mix thoroughly. Pour the mixture into three small bottles or test-tubes. Plug the test-tubes with absorbent cotton. Place one test-tube near a warm stove or radiator. Put a second on the ice in the refrigerator or in some other cool spot. Boil the mixture in the third test-tube for a few minutes and place it beside the first. Be sure that

all tubes are labelled to indicate clearly what has been done to each. After a few hours examine the contents of all three tubes. Notice the bubbles rising through the mixture in the first vessel. Remove the plug and quickly insert a glowing splinter into the mouth of the tube. If the splinter is dimmed or extinguished, the presence of carbon dioxide is indicated. Taste and smell the mixture. It has been *fermented* by the yeast. Examine a speck under a microscope. Observe and explain the results in the second and third test-tubes.



Yeast cells budding, greatly magnified. (Draw.)

In the first preparation in the foregoing exercise the microscope will reveal minute forms of plant life called *yeast*. They are one-celled, like bacteria, but are much larger and behave very differently. *Yeast plants are fungi.* They feed upon sugar, causing fermentation, which changes the sugar to alcohol. Like all other forms of plants, yeasts produce carbon dioxide while growing. They reproduce by budding as follows: a swelling appears on the yeast plant, grows larger, and finally separates from the parent plant. Look for buds when examining yeast under the microscope.

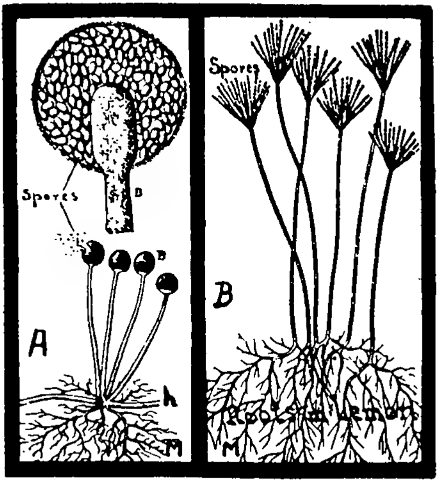
Commercial yeast is simply a mass of yeast plants that have been developed to a certain stage, then mixed with starch, dried, and pressed into small cakes. These yeast plants, when supplied with food, moisture, and warmth, start to grow. (See page 74 for a discussion of the "rising" of dough.)

Molds.—**Exercise.**—With a clean knife cut slices of fresh, moist bread and expose them to the air for 15 minutes. Place one slice in a test-tube and plug the open end with absorbent cotton to keep the bread moist. Dip a second piece in formalin and place in a test-tube and plug. A third slice is to be placed in a test-tube, plugged, and steamed. Leave all test-tubes in a warm dark place for several days. Prepare a moist slice and leave it in the light. Allow another slice to become thoroughly dry. Be sure that all test-tubes are carefully labelled. After two or three days make daily written observations.

In a few days a fine, white, hairlike growth appears on the bread in the first test-tube. This is a bread *mold*, and the threads are the roots or *mycelia* (sing. *mycelium*). Several days later black specks appear among the mycelia. These specks are *spore cases*, filled with fine, powdery bodies called *spores*. The spores reproduce the mold. (See page 107.)

Exercise.— (1) Why did no mold appear on the bread dipped in the formalin or on the dry or steamed bread?

(2) By means of a long wire dust some spores on the bread in the test-tube that was steamed. Hold the tube obliquely so that nothing can fall into it from the air. Before transferring the spores, heat the wire red hot and, as soon as cool, do the dusting. What is the object in heating the wire?



Two fungi. A, bread mold; B, lemon mold. Notice the mycelia (M), the spore cases (B), and the spores. All are very greatly magnified. (Draw.)

Molds are classed as fungi (sing. *fungus*). Examples of fungous plants are mushrooms, toadstools, puffballs, woody shelves or brackets that grow on trees, and the organisms causing rusts, smuts, mildews, and many other plant diseases. None of these plants contains chlorophyll, and therefore none of them can make starch. Why? They all exist on dead or living plant or animal matter.

Occurrence of Bacteria, Yeasts, and Molds.—The foregoing experiments should have demonstrated that bacteria and the spores of fungi are always present in the air. Fortunately most of them are harmless. They all

require food, moderate warmth, moisture, and air, and under favorable conditions develop very rapidly.

Decay.—Fermentation.—Sterilization.—Decay and fermentation are caused by the activity of bacteria or fungi. Yeasts ferment the juice of fruits. Wood rots when attacked by various fungi, and other fungi and bacteria are responsible for the spoiling of vegetables, meats, milk, and fruit. To prevent decay or fermentation the bacteria, yeasts, or molds must be killed. This process is called *sterilization* and is accomplished by heat or disinfectants, such as mercuric chloride, copper sulphate (bluestone), alcohol, formaldehyde, creoline, carbolic acid, etc. Low temperatures and dryness check fermentation and decay, but do not destroy the causes.

Bacteria in Disease.—It has been proved that special forms of bacteria (germs) are the cause of such diseases as colds, pneumonia, influenza, diphtheria, tuberculosis, typhoid fever, measles, boils, blood-poisoning, lock-jaw, and others. Disease-producing bacteria are called *pathogenic*. Infectious and contagious diseases are spread by transferring the bacteria from one person to another. How do doctors and nurses sterilize instruments and bandages? Sunlight is one of the best disinfectants. Pathogenic bacteria live but a short time when exposed to the direct rays of the sun.

Bacteria in Milk, in the Soil, and on the Roots of Plants.—These are very important in agriculture and are discussed on pages 16 and 226.

Useful Bacteria and Fungi.—Mushrooms are edible and may be grown in the garden. Bacteria and fungi in the soil maintain the supply of available plant food. Yeasts are essential in the baking of bread or in the manufacture of wines. The souring or ripening of milk and cream in the production of butter and cheese, and also the flavors produced in the different kinds of cheese, are brought about by

carefully controlled bacterial and fungal activity. Vinegar is produced by the action of yeasts and bacteria in hard cider. Bacteria also aid in the preparation of hemp and flax fibres and the tanning of hides to make leather.

Exercises.—(1) The following is a summary of some of the methods employed to control harmful bacteria and fungi.

- In milk
  - pasteurizing
  - sterilizing
  - cooling
  - cleanliness
- In meat
  - drying
  - salting
  - cold storage
  - canning
- In fruit
  - drying
  - preserving
    - boiling
    - sugar
    - sealing air-tight
  - cold storage
- In disease
  - cleanliness
  - disinfectants
  - sterilizing by steam
- In decay of wood
  - keeping dry
  - painting
  - disinfecting
- In eggs
  - cold storage
  - water glass

Discuss the methods mentioned above and explain how spoiling is prevented in each case.

(2) For further study read G. W. Hunter's *Civic Biology*, published by the American Book Company, Chicago; and other biology tests.

Cereal Rust.—The extent of the damage caused by this disease is hard to realize. In 1924 Mr. H. T. Güssow, Dominion Botanist, reported to the Select Standing Committee on Agriculture that "in some years the losses from wheat rust amounted to treble the amount which Canada derives from its fisheries. In 1916, one of the worst years of rust epidemics, the losses were equal to the entire mineral production of Canada in 1922, viz., $183,000,000."

The Black or Stem Rust of Wheat.—This disease is caused by a parasitic fungus that attacks principally the stems of the wheat plants. It develops and spreads most rapidly on damp cloudy days with no wind. Dry, hot, windy weather is unfavorable. The rust fungus feeds upon

the juice or sap in the wheat stem. As a result, the heads are starved, and small shrunken kernels are produced. Seed from a rusted crop will germinate, if not too shrunken, and produce a rust-free crop. The disease is transmitted only by spores.

Rust appears first about July, when small, red-colored openings are to be seen on the stems of the wheat. With an ordinary microscope these tiny slits are found to be filled with hundreds of red spores. These are the *summer spores* and are microscopic, red, thin-walled, one-celled bodies. They are easily detached from the eruption in which they appear and may be blown to other plants by the wind. When a red spore falls upon the stem or the leaf sheath of a wheat plant, it germinates when favorable conditions (warmth and moisture) occur. A very minute root penetrates the stem through a breathing pore. The root grows rapidly and soon branches into a mass of threads called a mycelium. In from eight to ten days after a red spore falls upon a wheat stem, special threads of the mycelium puncture the epidermis of the stem and produce new red or summer spores. These, in turn, are blown to other wheat plants, causing new infections. They may travel great distances in a day and carry the disease to wheat fields hundreds of miles away.

Courtesy of The Grain Growers' Guide, Ltd.
Black rust on the stem and leaf of wheat, the red stage on the left stalks and the black stage on the right one.

After some days, black spores appear in the openings and push the red spores out. The black spores are the *winter stage* of the fungus and are two-celled, thick-walled, and packed with food. They remain dormant on the straw and stubble during the winter months. In the spring the winter spores sprout, and each cell produces four

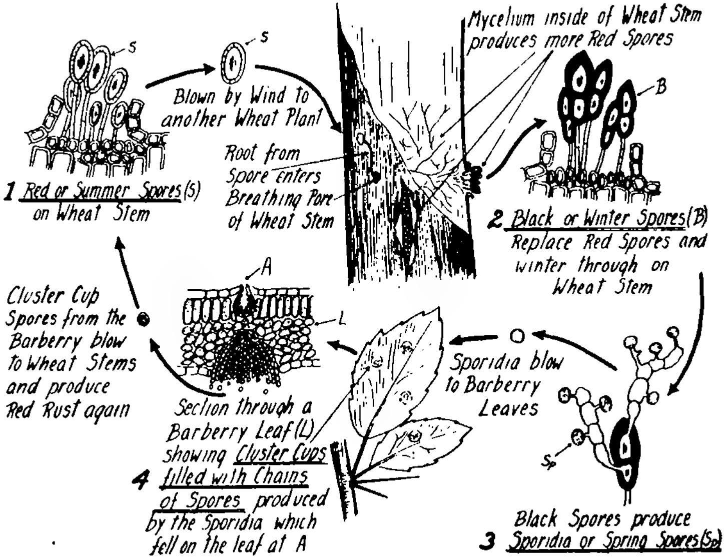


Diagram illustrating the four stages in the life history of the black or stem rust of wheat, as seen through a microscope. Follow the arrows.

spring spores or *sporidia*. The sporidia are blown by the wind to the leaves of the barberry, the only plant upon which they are known to live.

When the spring spores fall upon *barberry leaves*, they produce a root. This punctures the leaf and, when inside, develops a mycelium. In about twelve days, small, circular, cup-like clusters, filled with chains of yellow spores, appear. These are known as the *cluster-cup spores*. The

cluster-cup spores from the barberry are then blown back to the wheat or grass plants, where they germinate and grow, thus producing new outbreaks of the disease.

It is also possible that the red spores live through the winter on such perennial grasses as the wild barley, couch grass, and others.

Control of Rust.—Since the disease is not spread by the seed, seed treatment is useless. The only means of control are preventative measures.

(1) Destroy the barberry. Sweden and Denmark accomplished the eradication of this host plant several years ago and now report no severe outbreaks of rust. The United States is spending millions of dollars in the attempt to eradicate this noxious shrub. Barberry has been placed in the noxious weed list in Canada. It is now fairly certain that very few of these plants exist in Western Canada, still outbreaks of rust occur. Since the summer spores may travel thousands of miles, authorities state that it is possible for Manitoba wheat fields to be infected from sources in Minnesota. It is likely that the destruction of the barberry in the United States will do much to decrease the frequency and extent of the epidemics in this country.

(2) Encourage the crop to ripen before the rust season. Once the grain is mature and plump, the disease is powerless to damage the kernels. Early maturity is accomplished by sowing the crop as early as possible in the spring, using the best seed, preparing the best possible seed bed, and using an early-maturing variety of wheat.

(3) Grow varieties that have proved to be more or less rust-resistant. Some of the Durum or Macaroni wheats, such as Kubanka, etc., are to a large extent immune to the attacks of the fungus. (See Exercise No. 1, page 146.)

Exhaustive experiments are now being conducted at agricultural colleges and experimental stations in all parts

of the continent, and many of the best authorities on plant diseases are engaged in the search for methods of combating this destructive organism.

Exercises.—(1) Watch newspapers and magazines for accounts of rust research work being done in Western Canada.

(2) From the eruption on the stem of a wheat plant scrape off some red or black spores and prepare a microscope slide. Be careful not to remove too many. (See page 55 for directions for the preparation of the slide.) Slides of the four stages of rust may be obtained from firms supplying biological or agricultural equipment.

However, slides of the red or black spores may easily be prepared as above, and this should be the procedure where the spores are available.

(3) Make drawings of a red spore, a black spore, a black spore forming spring spores, a cross-section of a barberry leaf showing cluster-cups. Arrange in a circle to show the life cycle of the rust fungus. Name all parts.

Project.—About the end of June plant some wheat in boxes or flower pots. Then in July, when the plants are a good size, secure some red spores, if present, from the stems of wheat in the field. Rub the spores on various parts of the stems and leaves of the wheat in the boxes. In this way you should secure an outbreak of the disease in circumstances in which you may closely watch its development. Try infecting barley, oats, and rye with rust from the wheat.

Loose and Covered Smut of Wheat, Oats, and Barley.—These diseases are caused by certain fungi. While outbreaks of rust are mostly confined to the stem, smuts affect the seed.

The *covered smut of wheat*, also called *bunt* or *stinking smut*, is readily detected in bins of grain by its characteristic odor. During the summer, while the crop is growing, the smut fungus also grows within the wheat plant. Later, what should become the kernels develop into spore packages called *bunt balls*, which are filled with millions of spores. At threshing time the separator breaks the bunt balls, and the spores scatter. They become lodged in the creases and in the woolly ends of healthy kernels. There they

remain dormant until spring. If seeds carrying spores are planted, the spores germinate and infect the seedlings of the new crop with their mycelia, thus reproducing the fungus.

Courtesy of The Grain Growers' Guide, Ltd.

The smuts of wheat: (b) a wheat head infected with stinking smut (note the four smut balls); (c) a head partly infected with stinking smut; (a) a sound head; (d) two heads destroyed by loose smut. (After Güssow.)

The *loose smut of wheat and barley* destroys the entire head, leaving nothing but the central stalk, which is covered with fine black spores. These are blown to the flowers

of other plants, thus spreading the disease. This fungus passes the winter deep in the seed, and is, therefore, more difficult to destroy than the covered smut.

Control of Smut.—The covered smuts of wheat, oats, and barley, and the loose smut of oats, may be controlled by killing the spores with formaldehyde (formalin) or bluestone (copper sulphate). Formaldehyde is recommended, however, as it is less dangerous than the bluestone and less likely to injure the germinating power of the seed. The proper time to treat the seed is the night before it is to be sown. One method used is to pile the wheat on the floor of the granary and thoroughly sprinkle it with formalin solution (1 pint of formalin to 40 gallons of water). The pile must be stirred continuously while the sprinkling is being done to ensure every kernel being moistened. The seed is then covered for two hours, after which it is spread out to dry. It is strongly recommended that all seed wheat, oats, and barley be "pickled" before being sown. The use of copper carbonate dust for covered smut of wheat and hulless oats is now recommended. This fungicide is effective, easily applied, and does not injure germination. The seed should be thoroughly coated, at the rate of 2 ounces per bushel.

Courtesy of The Grain Growers' Guide, Ltd.

The smuts of oats: (a) covered smut; (b) naked or loose smut. (After Güssow.)

The loose smut of wheat and barley cannot be controlled with formalin. As the spores winter deep in the grain, and not on the surface, it is necessary to subject the seed to prolonged hot-water treatment. This is a long, tedious process, and there is great danger of destroying the germinating power of the seed. Fortunately, loose smuts are not very common in this country.

The fungus causing *smut in corn* may be checked by a rotation of crops and by avoiding the use of manure that is not well rotted on the corn land. *Rye smut* may be lessened by treating the seed with formalin.

Diseases of Potatoes.—There are many diseases affecting potatoes. The student who intends to grow this crop must not be content with the following brief discussion but should carefully study several of the government bulletins.

Blackleg is one of the most destructive potato diseases in Western Canada. It is detected early in the season by the presence of yellow or dead plants in the field and by soft, slimy, rotting condition in the tubers. This disease is caused by bacteria that winter in the tuber.

Courtesy of The Grain Growers' Guide, Ltd.
Rhizoctonia disease on potatoes, showing earth-colored spots.

Rhizoctonia is another very destructive potato disease. It is caused by a fungus that winters on the potato tubers and in the soil. This disease is identified by a closely curled appearance of the leaves at the top of the plants and small black spots on the tubers. The spots look like dirt, but will not wash off.

Common scab is a prevalent disease but apparently does not greatly reduce the yield. The skins of the diseased tubers become rough and pitted. This disease results

in heavy loss because scabby potatoes are not very saleable. The fungus that causes scab passes the winter either on the tubers or in the soil.

Many other diseases, such as *Fusarium wilt, dry rot, leaf roll, mosaic,* and others, must be recognized and controlled for success in potato-growing.

Courtesy of The Grain Growers' Guide, Ltd.

Common scab on a potato tuber.

Control of Potato Diseases.—All seed potatoes should be soaked for two hours in one of the following solutions: corrosive sublimate (mercuric chloride), 4 ounces to 30 gallons of water, recommended to reduce common scab, blackleg, and Rhizoctonia; or formalin, 1 pound in 30 gallons of water, for common scab only. Discard all potatoes showing signs of disease. The knife used to cut potato sets should be dipped in a strong solution of formalin if it passes through a diseased spot. During the summer potato crops must be carefully rogued. This consists of removing and destroying all diseased plants that are detected during the growing season. Strong, vigorous, disease-free plants should be marked during the summer, and the tubers from these plants should be selected for seed. Since the fungi causing common scab and Rhizoctonia winter in the soil, it is necessary to avoid growing potatoes on the same land more often than once in four or five years. A well-planned crop rotation is essential for the production of disease-free potatoes. To control late blight, a disease not common in Western Canada, the leaves of the potatoes are sprayed with Bordeaux mixture. The spores of the late blight fungus are blown from one plant to another by the wind; but when the leaves have been well sprayed, the spores are destroyed before the new plants become infected.

Preparation of Bordeaux Mixture.—Dissolve 4 pounds of copper sulphate (bluestone) in 4 gallons of water. Mix 8 to 9 pounds of slacked lime in 4 gallons of water. Now add 32 gallons of water to the copper sulphate solution and strain the lime into it. Use only wooden or earthenware vessels. Consult government bulletins for further directions. Bordeaux mixture is mentioned because it is a very effective *fungicide* and is widely used to control many plant diseases. If ½ pound of Paris green is added to the above mixture, it is effective against insects as well as fungi.

Diseases of Fruit Trees.—The successful fruit-grower must be continually on the watch for the appearance of disease in his orchard. If discovered early, many of these diseases may be checked by pruning and burning the diseased branches. Frequently, when serious outbreaks occur, it is necessary to spray the trees or bushes with a suitable fungicide, such as Bordeaux mixture or lime-sulphur. Lime-sulphur is a commercial product. It is prepared in three different strengths and is used for the control of fungous diseases of apples, pears, peaches, plums, cherries, and other fruit trees.

Damping-off Disease.—This disease is common in green-houses and hot-beds. It is caused by a fungus that lives, for the most part, in the soil. Under favorable conditions healthy plants may be attacked and die very quickly. The development of this disease is encouraged by excessive dampness, poor ventilation, and darkness. Its control is accomplished by remedying these causes.

Exercises.—(1) It is likely that a great deal will be accomplished in the near future to produce disease-resistant varieties of crops by careful selection and cross-breeding. Watch the papers carefully for announcements about new varieties of wheat and other crops.

(2) Make a list of the fungicides (preparations for the control of fungi) which have been discussed. Give examples of the diseases against which each fungicide is used.

(3) Ten methods of controlling plant diseases have been discussed in this chapter. Make a summary in tabular form of these methods,

give examples of diseases controlled in each case, and explain how each method is effective. The following arrangement is suggested:

Methods	Diseases controlled	How effective

(4) The foregoing discussions should be supplemented by reading bulletins from provincial and Dominion Departments of Agriculture.

CHAPTER X

INSECTS—EARTHWORMS—BIRDS—GOPHERS

Over one-half of the species of animals in the world are insects. They are so widely distributed and so numerous that it is sometimes said that we are living in the age of insects. All have very similar characteristics, so that if one insect is carefully studied, a good idea may be formed of all animals of this class.

The Characteristics of an Insect.—**Exercises.**—(1) Obtain several grasshoppers, flies, moths, butterflies, beetles, and other insects. Living specimens may be placed under glass tumblers for observations. Closely examine each insect and tabulate their general characteristics as follows:

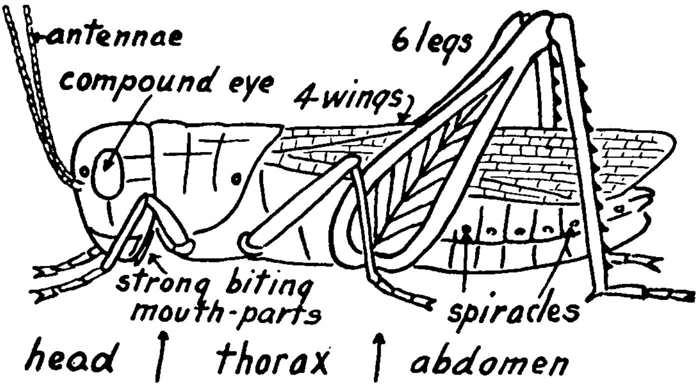
Insect	No. of Legs	No. of Wings	No. of Parts to Body	Attachment of Wings and Legs	Antennae or Feelers
Grasshopper...	3 pairs	4	3	to thorax	2
Butterfly......	3 pairs	4	3	to thorax	2
Moth...........	3 pairs	4	3	to thorax	2
Beetle.........	3 pairs	4	3	to thorax	2
Bee............	3 pairs	4	3	to thorax	2
Etc............					

Do you find them to be alike in any respects?

(2) Now examine a grasshopper more in detail. The three parts of the body are known as the *head*, the *thorax*, and the *abdomen*. To which part are the wings and legs attached? The *smelling organs* are located in the *antennae*. The grasshopper has three simple eyes in the front of its head and two large *compound eyes* on either side. Notice its *strong cutting mouth parts*. The food tube, or *alimentary canal*, is composed of the following parts in order: an enlarged crop-

like part, the gizzard where poorly chewed food is further broken up, the digestive and excretory organs. Look along each side of the abdomen for a number of small openings. These are the *breathing organs* or *spiracles*. The grasshopper has no lungs but has, instead, a series of fine branching tubes. Locate the *hearing organs* on the first segment of the abdomen. Observe the hard outer covering of the body. This forms the skeleton of the grasshopper, and, because it is on the outside of the body, it is called an *external skeleton* or an *exoskeleton*. In what respects are the hind legs of a grasshopper especially adapted for jumping and landing?

It will be found that the general characteristics of the grasshopper are typical of all insects, although not all insects have four wings.

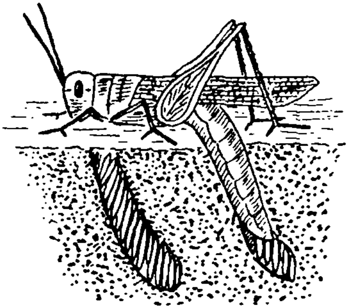


The parts of a grasshopper, a typical insect. (Draw.)

An insect is an animal that has its body divided into three parts, has antennae and six legs, breathes by means of air tubes, and, after hatching from the egg, passes through a metamorphosis before becoming an adult.

The Life History of Insects.—Metamorphosis (*meta*, change; *morphe*, form).—All insects begin life as an egg. After hatching from the egg, the insect undergoes a distinct change in form before reaching the adult stage. These changes are more pronounced in some insects than in others.

(*a*) *A typical complete metamorphosis.*—The bodies of many insects, such as butterflies, moths, bees, ants, beetles, flies, and others, undergo a complete change in form as they develop to maturity. There are four stages of growth. The *egg* is laid by the adult on or near food for the larvae. The *larva* (pl. *larvae*) hatches from the egg and does little but eat and grow. The larvae of moths and butterflies are called caterpillars. The larva of the fly is known as a maggot. The *pupa* (pl. *pupae*) is sometimes called the resting stage; when the larva has become full grown, it builds a case around itself, and during the period that it remains in this case its body is rebuilt into an adult insect. The pupa of a moth is called a cocoon, and that of a butterfly a chrysalis. The *imago* or *adult* emerges from the pupa case full grown, when the metamorphosis is completed.



A grasshopper laying eggs.

(*b*) *A typical incomplete metamorphosis.*—Except that it has no wings, the body of a newly-hatched grasshopper does not differ a great deal from the body of a full-grown adult. The grasshopper, therefore, during its growing process does not pass through as complete a change in form as described above. For this reason it is said to have an incomplete metamorphosis. There are three stages in its life history. The insect begins life as an *egg*. From the egg hatches the *nymph* or *young grasshopper*. The nymph molts, that is, sheds its skin or exoskeleton, a number of times during its growth. After the last molt it has wings and is a complete *adult*. The molting period requires practically all summer, and during the process the nymphs feed extensively. The

female grasshopper lays its eggs, in small waterproof cases, on the sunny sides of grassy knolls in the fall. Crickets, bugs, dragon flies, and aphids are some of the other insects that undergo an incomplete metamorphosis.

The Classification or Orders of Insects.—While the names of the common orders of insects, as outlined below, need not be memorized, they are convenient for reference in the identification of specimens.

No

NB

Orthoptera—straight wings—grasshoppers, crickets.
Hemiptera—half-winged—bugs, aphids.
Coleoptera—sheath or hard wings—beetles.
Hymenoptera—membrane wings—ants, bees, wasps, saw-flies.
Odonata—lace-like wings—dragon flies.
Ephemerida—short-lived—May flies.
Lepidoptera—scale wings—butterflies, moths.
Diptera—two wings—flies, mosquitoes.

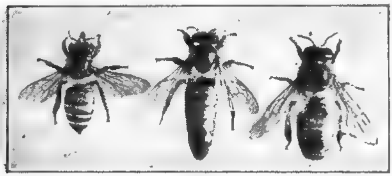
Beneficial Insects.—It is a very serious mistake to kill, on sight, every insect one finds. Many are decidedly beneficial and should be protected and encouraged to multiply rather than destroyed. Bees are perhaps the most useful to man. Many flowers depend upon insects for the transfer of pollen from anther to stigma. In some localities, where bees are not common, gardeners must, themselves, pollinate their squash, melon, and similar crops. The economic importance of the silk worm is well known.

There is also another way, less commonly known but extremely useful, in which many insects are helpful to man. The tachina fly lays its eggs on the bodies of many injurious larvae, and the young maggot (larva), which hatches from the egg, destroys the caterpillars. The ladybird or ladybug, which is a beetle, in both the adult and the larva stages feeds upon plant lice, potato beetles, and other harmful insects that attack trees and garden crops. Carrion beetles perform valuable service in the destruction of dead animal

bodies. These are only a few of the parasitic insects which man now regards as friends rather than enemies.

Bees.—Bees are valuable as producers of honey and wax and as distributers of pollen. The honey is produced from nectar gathered from flowers, and the wax is secreted from small pockets on the under-side of the abdomen. The hind legs of the bee are each provided with a tiny sac for carrying pollen.

Bees live in well-organized colonies. Each colony usually consists of a queen, a few hundred drones, and thousands of workers. The *queen bee* is much larger and longer than the workers and is a perfect female. She lays all the eggs from which the young of the colony are produced. The *workers* are undeveloped females. They perform the work of the hive, such as gathering nectar and pollen, producing honey and wax, feeding and caring for the young, and protecting the hive from robber bees. The *drones* are the males. Only the workers sting—the drones have no stinging organs, and the queens use theirs only to destroy rival queens. The cells in the honeycomb are hexagonal and are built of wax.

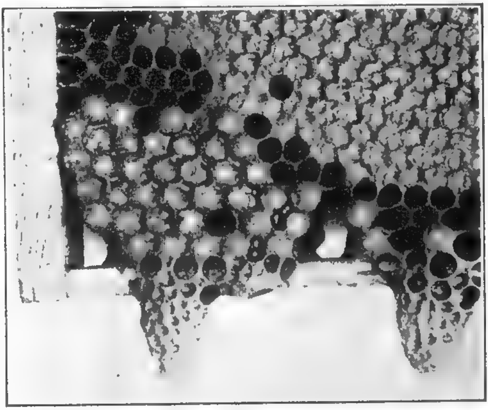


Courtesy of Dominion Experimental Farms Branch, Ottawa

A worker bee (left), a queen bee (centre), and a drone (right).

Bees undergo a complete metamorphosis. Early in the spring the queen begins to lay eggs in worker cells, which are about $\frac{1}{5}$ inch in diameter. When the larvae are full grown, the worker bees cap the cells, and the young bees pass into the pupa stage. In twenty-one days after the egg was laid, a worker emerges. Later the queen deposits eggs in drone cells, which are approximately $\frac{1}{4}$ inch across. These are filled with convex caps and produce drones. Finally the workers build specially constructed queen cells

over certain worker cells, and the larvae within are fed an excess of rich food. Such cells will produce queens. After the queen cells are built, the old queen and part of the colony swarm, that is, leave the hive. The first young queen to emerge usually destroys the others by stinging them. Four or five days after she emerges, the queen leaves the hive for a few days to mate with a drone, after which she returns to fulfil her function of laying eggs.



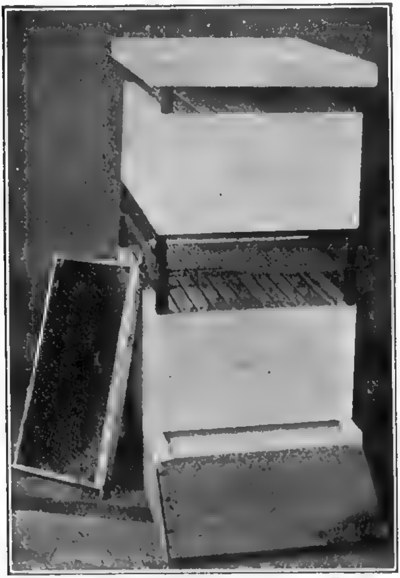
Courtesy of Dominion Experimental Farms Branch, Ottawa

Capped worker cells (upper right-hand corner), drone cells (lower left-hand corner of frame), and two queen cells (hanging from lower edge of frame).

The care of bees.—The *apiary* should be located in a grove of trees that will provide effective shelter from strong winds. The hives should be shaded during the hottest part of the summer days, but must also be exposed to a certain amount of sunlight. It is very desirable to have a plentiful supply of honey plants, such as willows, fruit trees, dandelions, sweet clover, alfalfa, fireweed, golden rod, etc., within two or three miles of the apiary. Italian bees, which may be identified by yellow bands around the abdomen, are by far the most popular, although there are a few apiaries of black hybrid and carniolan bees. The primary object of the bee-keeper is to maintain his colonies large and strong, and to prevent swarming. Bees usually swarm when there is a lack of food or room in the old hive. Preparations for

swarming may be detected by the presence of eggs in queen cells in the brood chamber.

The most common type of hive is the Langstroth. Each hive consists of a lower section or brood chamber in which the young are raised, and upper sections, called supers, in which the surplus honey is stored. The supers are added as the flow of honey increases, and the queen is kept out by a queen excluder or screen through which the workers only can pass. The hives are supplied with movable frames, $17\frac{5}{8}$ inches long and $9\frac{1}{8}$ inches deep, and the honey is produced and the young are raised in wax cells built in these frames. To make the work of the bees easier the frames are fitted with sheets of wax upon which the pattern of the comb cells has been stamped. The bees draw this wax out to make the cells. The hives must be examined at frequent intervals to detect disease or other unfavorable conditions. If the bees are first smoked and then handled gently, there is little danger of being stung. The honey is marketed in the comb or extracted from it by a machine.



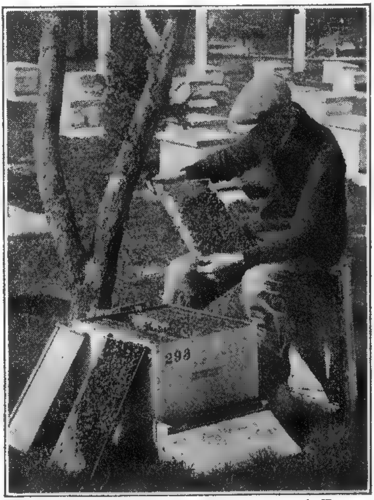
Courtesy of Dominion Experimental Farms Branch, Ottawa

A 10-frame Langstroth hive spread out to show the parts. From bottom to top—stand, floor and entrance, brood chamber, queen excluding screen, super, and cover. A frame for the comb, with a wax foundation, stands beside the hive.

A great deal of the success in raising bees depends upon how they are stored during the winter. They may be

wintered in a dark, cool, well-ventilated cellar, or in well-packed cases out-doors. Every effort must be made to have the colonies strong and vigorous for the winter, and they must be supplied with sufficient honey and sugar syrup for food.

Note.—For further study of bees send for Bulletin No. 33, *Bees and How to Keep Them,* Publications Branch, Department of Agriculture, Ottawa.



Courtesy of Dominion Experimental Farms Branch, Ottawa

Examining the comb.

Injurious Insects.—Injurious insects are divided into two classes: (*a*) those with *biting mouth parts,* such as the cutworm, potato beetle, cabbage butterfly, grasshopper, etc., which feed upon the stems, leaves, and roots of plants; and (*b*) those which have *sucking mouth parts,* such as the aphids or plant lice, which bore into the plants and then suck the juices.

Each of these classes must be controlled by different methods. The insects with biting mouth parts are destroyed by *stomach poisons,* placed on the ground or on the plants. These are discussed in the following paragraphs. Such methods would be ineffective against insects with sucking mouth parts, since they feed only upon the juices inside the plant. They must be controlled by *contact sprays,* which will destroy their bodies or fill up their breathing pores.

Plant lice may be smothered by *kerosene emulsion,* made up as follows: dissolve ½ pound of hard soap in 1 gallon of boiling soft water; remove from the fire; pour the hot solution

into 2 gallons of kerosene, and stir vigorously for 5 minutes. For use, dilute this stock mixture with 9 parts of water. Another useful contact spray is a *tobacco extract*, made by steeping 1 pound of tobacco refuse in 1 gallon of water for 1 hour and applying at once. *Whale oil soap*, 1 pound in 4 to 6 gallons of soft water, is recommended to destroy aphids.

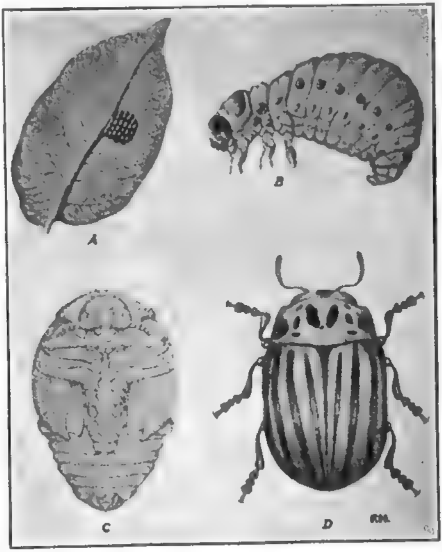
The Imported Cabbage Butterfly.—The adult is a yellowish white butterfly with black markings on the tip and other parts of the wing. They are very common and may be seen during the summer flying over cabbage or turnip patches. The eggs are laid upon the heads of the cabbages or related plants and hatch in a few days. For about three weeks the greenish-colored larva feeds upon the leaves of the cabbage plant. It then passes into the pupa stage, from which, after a three-week period, the adult emerges. The cabbage butterfly is usually double brooded; that is, it passes through its life history twice in the year. Verify this statement by checking very carefully the above facts.

Poison sprays are effective against this destructive insect. Early in the summer *Paris green*—½ pound of Paris green, 2 pounds of fresh lime, 40 gallons of water—may be used; but later, as the cabbage becomes ready to use, a vegetable spray, harmless to man, such as *white hellebore*—1 ounce to 1 gallon of water—should be substituted.

The Colorado Potato Beetle or Potato "Bug".—Both the adult and the larva feed ravenously upon the leaves of the potato plants and will completely defoliate an entire patch unless checked as soon as they are discovered. The adults, which are not bugs but beetles, pass the winter in the ground. In the early spring they emerge, and the female lays its orange-colored eggs as soon as there are young potato plants. The eggs hatch in a week or ten

days. The larvae are full grown in two weeks, when they bury themselves in the ground to pass the pupal stage. The adult emerges from the pupa case in about two weeks more. They at once lay more eggs for a second generation, which by fall will have reached the adult stage.

Control is accomplished by the use of arsenical sprays, such as *Paris green* or *arsenate of lead.* The recipe for the lead arsenate poison is 1½ pounds of powder to 40 gallons (1 barrel) of water.

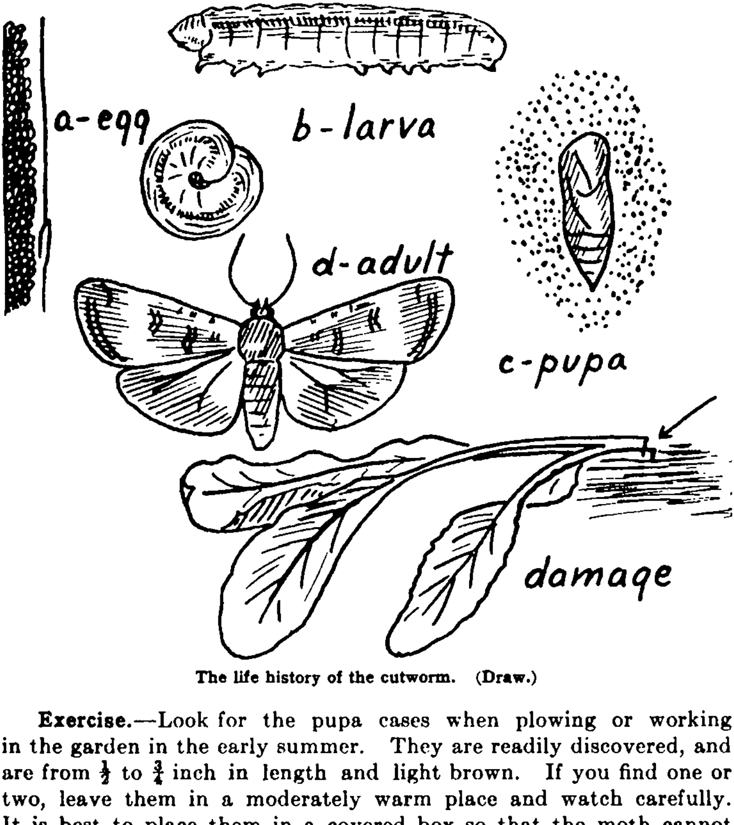


The Colorado potato beetle. A, eggs on a leaf; B, the larva; C, the pupa; D, the adult beetle. (After Hudson, Ent. Br., Dom. Dept. of Agric., Bulletin No. 52, N. S.)

The Cutworm.—The cutworm is one of the most destructive insects with which the farmers of Western Canada have to contend. Two species are especially important, the Red-backed and the Pale Western.

The adults in each case are greyish-brown, medium-sized, night-flying moths, commonly known as moth millers. The moths lay their minute, pale-colored eggs on the ground, or on the leaves of weeds, grasses, trees, etc., during the summer and early fall months. The majority of eggs do not hatch until the middle of April. The larvae are smooth, cylindrical, soil-colored caterpillars about 1½ inches long. By the middle of June the larvae are full grown and pass

into the pupa stage. Small, oval, earthen cells are formed, in which the cutworm remains for about a month, when the adult moth emerges and at once begins to lay numerous eggs.



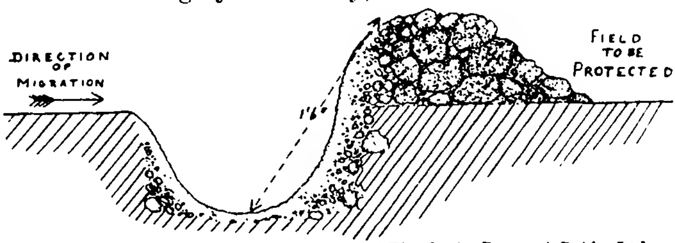
The life history of the cutworm. (Draw.)

Exercise.—Look for the pupa cases when plowing or working in the garden in the early summer. They are readily discovered, and are from ½ to ¾ inch in length and light brown. If you find one or two, leave them in a moderately warm place and watch carefully. It is best to place them in a covered box so that the moth cannot escape until you have had an opportunity to see it.

Cutworms attack all crops of field and garden. During the day the larvae remain underground, coming to the surface at night to feed. They move more freely in dry,

loose soil and do most damage in dry seasons. Usually they do nothing more than cut the plant off just below the surface of the ground, then pass to the next plant destroying it in the same manner. Some cutworms climb into the trees, bushes, and plants like the tomatoes, and feed upon the leaves and fruit.

Control measures are: (1) Poison with *bait* prepared as follows:—50 pounds of *bran* or *shorts*, 1 gallon of *molasses*, 1 pound of *Paris green* (works more quickly) or *arsenic* (cheaper), and 1½ gallons of *water*. The bran and Paris green are thoroughly mixed dry, and the molasses is stirred



Courtesy of The Grain Growers' Guide, Ltd.

Diagram of a furrow to stop the advance of cutworms. (After Strickland.)

into the water, after which the dry ingredients are added to the liquid. The above mixture should cover 6 or 7 acres. For small areas a quart of bran, a tablespoon of molasses, a teaspoon of Paris green with sufficient water to moisten will make a smaller quantity in the correct proportions. The bait should be spread thinly over the ground in the evening. Why? (2) Deep fall plowing will bury the eggs on the ground or on any plants in the field so deeply that they will not hatch. (3) Clean fields and gardens will reduce the number of egg-laying locations. (4) A tin or paper cylinder placed around young plants, so that it extends a few inches above and below the surface of the ground, will afford an effective protection. (5) A deep furrow will stop the advance of the Army cutworm or other species on the march.

The furrow should be turned away from the direction in which the cutworms are travelling. Insects that are trapped in the furrow may be destroyed by means of poisoned bait or by crushing them. An undamaged garden may be protected by this method.

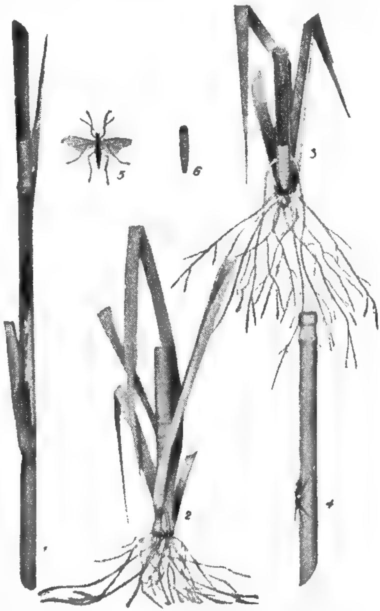
Control of Grasshoppers.—These insects have biting mouth parts and, therefore, must be controlled by stomach poisons. Grasshopper *bait* is prepared as follows:—Mix 50 pounds of *bran* with an equal bulk of *sawdust.* Add 4 to 5 pounds of *white arsenic* (or Paris green) and stir thoroughly. Next mix 3 ounces of *amylacetate* (or 12 finely chopped-up lemons) with 1½ gallons of *blackstrap molasses.* Then add 10 to 13 gallons of *water* to the amylacetate-molasses mixture, and finally add the wet mixture to the dry bran and sawdust and mix very thoroughly. This bait should be spread thinly over the ground early in the day during hot, dry weather. Why? A second mixture may also be prepared by substituting 6 pounds of *salt* for the molasses and amylacetate in the above recipe. Cultural methods, such as deep fall plowing, are also useful to control grasshoppers. Explain in what way. Can you name any insect or bird enemies of the grasshopper?

The Wheat-stem Saw-fly.—This insect has in recent years caused a great deal of damage to the wheat crops of Western Canada.

The adult is a four-winged insect, black in color, with three yellow bands on the abdomen and yellow legs. It is about ⅓ inch long. Look for it any time from June 1st to the middle of July. It is easily discovered resting head downward upon the stems of grain or grasses. During the last two weeks of June the females are busy laying tiny, white, cylindrical eggs on the stems of the wheat, just above the top joint. These eggs hatch in from three to four days. Immediately the larvae, which are about ½ inch long and

white, begin to work their way down through the stem, eating the inner part as they go. About August 1st they reach the roots and cut the stem off at the surface of the ground. The stub of the stem is then sealed, the larvae remaining there until the following June, when, having pupated during the winter, they emerge as adults.

The presence of the larvae is at first detected by a blackening of the stems near the joints. If the stem is examined, the tunnels made by the larvae as they travel downward and the dust left are readily discovered. During the latter part of July the stems will be noticed breaking after wind or rain. Just before cutting time the plants will be found to be severed at the surface of the ground.



Courtesy of The Grain Growers' Guide, Ltd.

The western wheat-stem saw-fly: (1) the straw cut open to show the tunnelling of the larva; (2) the base of the plant showing how the base is severed near the ground; (3) a stub with the larva in winter position; (4) a portion of the stem showing the characteristic resting attitude of the saw-fly; (5) the female saw-fly; (6) the mature larva. The illustrations are about one-half the natural size. (After Criddle.)

To control the saw-fly.—(1) All infested stubble should be plowed at least 5 inches deep, between August 1st and the following June. This buries the larvae so deeply that they cannot reach the surface. When plowed in the spring, the land should be packed; otherwise the insects will succeed in breaking through the soil. The practice of sowing crops on stubble

land is found to encourage the development of the flies and is condemned on this account. (2) All infested grasses adjacent to growing crops should be cut between the middle of July and August 1st to destroy the larvae before they reach the ground. (3) If the saw-fly is found to be present and the wheat is cut about August 1st, much of the crop may be saved.

Exercises.—(1) As each insect is studied, a series of drawings should be made to illustrate its life history and distinguishing characteristics. It is important to show clearly the attachment of the appendages (legs, wings, etc.). The outstanding parts of each drawing should be named, such as the wings, legs, etc., of the adult and the mouth parts of the larva. Drawings of larvae will be much more easily made if the particular characters of the larva under consideration are first studied as follows: count the number of segments in the entire body; then, counting from the head, observe which of the segments have legs and which have not, and so on. If this is done, anyone can make a fairly satisfactory drawing. It is not suggested that this detailed examination of the larva be used for any purpose except to facilitate the making of the drawing.

(2) A spider has eight legs, two parts to its body, and no antennae. Is it an insect? Give reasons.

(3) Collect pupa cases that you may find. Dissect a few. In some you should find the larva; in others, more mature, the adult almost ready to emerge. Place several away, still attached as you found them, if possible, and watch for the adult. Do not be too anxious for results. Some adults may not emerge for several months.

(4) Caterpillars may be collected and placed in glass jars or boxes covered with wire netting containing moist earth or sod. Supply them with the same kind of leaves as they were feeding upon when you found them. Watch for the cocoon-making operations to begin.

(5) Look for grasshopper eggs early in the spring. Put some in a bottle, loosely corked, and place in a warm, sunny location. In a short time they will hatch out. Observe the size, color, and characteristics of the nymphs.

(6) Watch for the nymphs in field and garden. In the spring and early summer they are quite easily discovered if one is on the lookout for them.

(7) If other insects are more injurious in your district, they should be studied before those mentioned above.

(8) Are the cutworms, silkworms, etc., properly named? Is it correct to call an insect a worm at any stage of its life history?

(9) Make a summary in tabular form of the methods employed to control insect pests. Name several insects that may be destroyed by each method which you suggest. Make a separate list of insecticides or poisons and give examples of the insects against which theinsecticide is effective. Are the insecticides which you mention stomach or contact poisons?

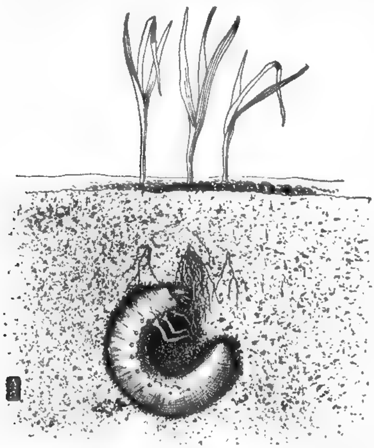
A wheat wireworm feeding upon the roots of a wheat plant, and the adult which is a click beetle. (After Hudson, Ent. Br., Dom. Dept. of Agric., Circular No. 2.)

Projects.—(1) Make a collection of 50 or more species of insects. Write for *Directions for Collecting and Preserving Insects*, Pamphlet No. 14 N. S., Department of Agriculture, Ottawa.

(2) Prepare specimens of the various stages in the life history of a number of insects; for example, the potato beetle. The adults, larvae, and eggs of this pest are easily found on the potato plants. Look in the soil for the pupae, or in the fall place several larvae in a box or glass jar containing moist earth and feed with fresh potato leaves until they pupate.

(3) Students who are caring for gardens should be familiar, at least, with the characteristics, nature of the damage, and the control of the following insects, as well as those mentioned in the foregoing paragraphs: the various species of *flea beetles*, which are quite small

and eat holes in the leaves of turnips, radishes, potatoes, tomatoes, cucumbers, cabbages, beans, squashes, and a number of flowering plants; the soft, slender-bodied *blister beetles*, which feed on potatoes, beans, beets, carrots, tomatoes, and flowering plants; the *root maggots*, which destroy the roots of cabbages, cauliflower, radishes, turnips, grasses, grains, and onions—the adults are flies; the *white grubs*, which are the larvae of the common May beetles or June bugs and attack the roots of garden and field crops; the slender, hard, shiny, brownish *wireworms*, which are the larvae of click beetles and damage onions, potatoes, grasses, and cereals; the *currant saw-fly*, and others.



White grub feeding on the roots of grasses. (After Gibson, Ent. Br., Dom. Dept. of Agric., C. P. Leaflet No. 5.)

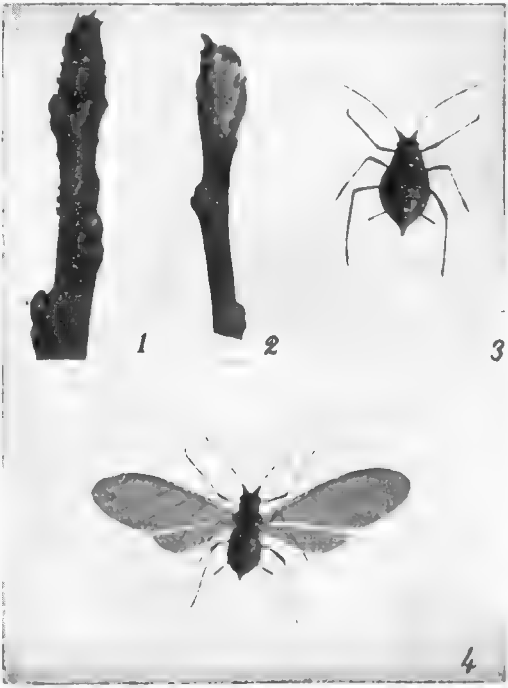
A potato flea beetle (much enlarged).

The bulletin *Common Garden Insects and Their Control*, Circular 9 E.B., and others which may be selected from the *List of Publications* (see page VIII), are recommended. Send for the bulletins on insects published by the Department of Agriculture in your province.

Earthworms.—Earthworms are very important because of the good work which they do in pulverizing, aerating, and stirring up the soil, which is their chief food. They take the soil into their bodies, absorb the digestible parts, and excrete the remaining and larger portions. This process has a pulverizing effect upon the soil. The burrows of the earthworms make openings for the entrance of water and air into the soil, and their digging activities constantly bring large quantities of new soil to the surface of the ground.

The Balance of Nature.—In the scheme of nature a rigid balance is maintained between the various forms of

life. Natural enemies and limited food supplies effectively prevent the excessive increase of any species of plant or animal. When man sets up unnatural conditions, as he does by growing cultivated crops, the balance of nature is destroyed. The abnormally large supply of available food results in an increase in the number of insects, and in order to save the crops a continuous battle must be waged by farmer and gardener. Why? Are weeds also the result of man's interference in the balance of nature?



Plant lice or aphids: (1) eggs on a twig; (2) recently hatched aphids on a bud; (3) the wingless aphid; (4) the winged aphid; (3) and (4) are much enlarged. (After Ross, Ent. Br., Dom. Dept. of Agric., Pamphlet No. 31.)

The Value of Birds in Agriculture.—Insects are responsible for tremendous losses. In Canada, alone, they damage trees and crops to the extent of $200,000,000 annually. *Birds are the natural enemies of injurious insects.* It would seem to be a sound "dollar and cents" proposition to encourage, by every means possible, an increase in the number of birds in Western Canada. *Birds are also weed-*

seed-destroyers. Many of our summer birds and the 43 species of our winter birds live principally upon weed seeds.

WHAT SOME OF THE BIRDS EAT*

Bluebird—68% insects,—grasshoppers, beetles, caterpillars.

Kingbird—85% insects,—flies, mosquitoes, locusts, blister beetles, crickets, cutworm moths.

Meadowlark—ground beetles, caterpillars, cutworms, army worms, grasshoppers, weevils, 24% weed seeds.

House Wren—grasshoppers, beetles, bugs, spiders, cutworms, wood ticks, plant lice.

Chickadee—70% insects,—moths, caterpillars, beetles, ants, wasps, bugs, flies, spiders, and poison ivy berries and weed seeds.

Franklin's Gull—This is the gull that follows the plowman. Its food is grubs, cutworms, dragon flies, beetles, ants, grasshoppers, wireworms, click beetles, May beetles, weevils.

Robin—58% wild berries, 42% worms and insects.

Song Sparrow and Chipping Sparrow—noxious weed seeds, beetles, weevils, ants, wasps, bugs, caterpillars, plant lice.

Hawks—with the exception of Sharp-shinned, Cooper's, Pigeon, and Goshawk, do not maliciously attack poultry but destroy insects, mice, and gophers.

Owls—The Great-Horned or Cat Owl is the only one that destroys Poultry.

Exercise.—What birds are harmful? What is the nature of the damage? How can harmful birds be destroyed? Are any birds, usually considered harmful, beneficial in some respects.

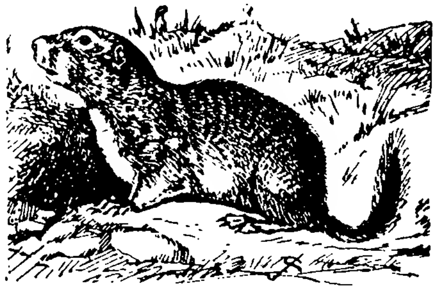
Gophers and their Control.—Four types of gophers are found on the Canadian prairies; the common grey Richardson gopher, the striped gopher, the mole or pocket gopher, and the squirrel tail or scrub gopher. The Richardson gopher is the most common and causes the greatest damage. The pocket gopher is also a bad pest in some districts.

Gophers may be controlled by poisoning, shooting, trapping, suffocating, etc. Poisoning seems to be the most

*From *Extension Bulletin No. 52, Manitoba,* by V. W. Jackson.

effective method of destroying the Richardson gopher. The following mixture is recommended:

Dissolve 1 ounce of *strychnine sulphate* in 2 quarts of *hot water* (or 1 ounce of *strychnine alkaloid* in 1 quart of *vinegar* to which has been added 1 quart of *hot water*). Stir until all the strychnine is dissolved, boiling if necessary. Add 1 pound of *sugar* or 1 pint of *molasses*, and 1 teaspoonful of *oil of anise*. Pour the hot solution over ½ bushel of *wheat*, and, if necessary, add enough hot water just to cover all the wheat. Let the grain stand in the solution for 24 hours. If any of the solution is then unabsorbed, add a handful of shorts and stir the whole mixture well.



Courtesy of Biology Department, Manitoba Agricultural College

The flickertail or Richardson gopher, the most common and most destructive gopher of the prairies.

The poison mixture should be used early in the spring. Why? A tablespoonful is sufficient in each hole, and if it is placed deep in the hole, fewer birds will be poisoned. The pocket gopher apparently is best controlled by trapping.

CHAPTER XI

TYPES AND BREEDS OF FARM ANIMALS

A remarkably large number of the breeds of horses, cattle, sheep, swine, and poultry were produced by the early live stock breeders of England and Scotland. In many parts of the world there are breeds of farm animals, such as the Corriedale sheep of New Zealand, the Brown Swiss cattle of Switzerland, etc., that are not raised in Western Canada. These breeds have been developed to meet the particular requirements of the country in which they are found, and in most cases are not suited to our conditions. Only the breeds most commonly raised in the Prairie Provinces are discussed in the following pages. Any of them may be considered as suitable in general for western purposes, except where their specific value is definitely outlined.

Type and Breed Defined.—A *type* is a class of animals possessing general characteristics that make them especially suitable for a certain purpose; for example, the beef type of cattle or the draft horse. A *breed* is a class of animals which are descended from the same ancestors and have similar general characteristics; for instance, the Percherons, Shorthorns, etc.

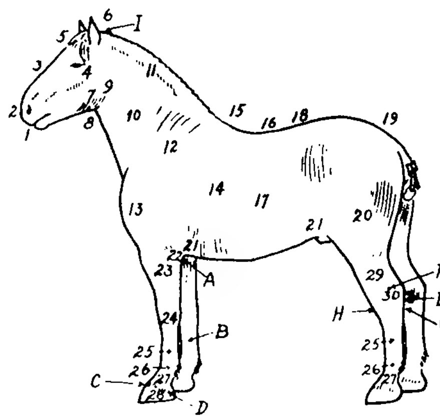
Classification of Horses.—Horses are classified according to type and size, and their suitability for various kinds of work, as follows:

Draft Horses	*Heavy Draft*—from 1800 to 2200 pounds and over —dray horses.
	Light Draft or *Agricultural*—from 1600 to 1800 pounds —farm horses.

Light Horses

- *Heavy Harness* or *Carriage*—from 1100 to 1500 pounds —a fairly large driving horse.
- *Light Harness* or *Roadster*—from 1000 to 1250 pounds –a lighter faster horse for driving and racing.
- *Saddle Horses*—polo ponies, 850 to 1000 pounds—cavalry horses, 950 to 1100 pounds—hunters, 1000 to 1250 pounds—riding horses for speed and endurance.

The Draft Horse.—The draft horse has been developed for moving heavy loads. Horses of this type are large, heavy, deep, thick, lowset, compact, and muscular. Explain each of these terms. The head of the draft horse should be of medium size and broad between the eyes. A large, bright, prominent eye indicates intelligence and an energetic disposition. The neck should be full and muscular and well blended into the shoulder. The desirable shoulder is sloping and well muscled, with a good collar-seat. Why is each of these characteristics essential? Strength of constitution is indicated by a broad, deep chest and a large heart-girth. The back should be short, broad, and heavily muscled.

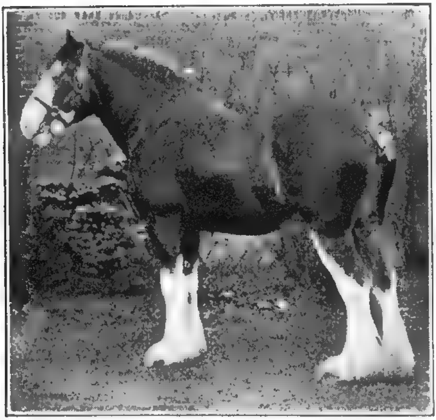


THE POINTS OF A HORSE

1. mouth.	11. crest.	21. flank.
2. nostril.	12. shoulder.	22. elbow.
3. face.	13. chest.	23. forearm.
4. eye.	14. heart-girth.	24. knee.
5. forehead.	15. withers.	25. cannon.
6. poll.	16. back.	26. fetlock.
7. lower jaw.	17. middle.	27. pastern.
8. throat.	18. loin.	28. hoof.
9. throat latch.	19. croup.	29. gaskin.
10. neck.	20. thigh.	30. hock.

LOCATION OF UNSOUNDNESS

A. capped elbow.	E. bone spavin on inside of leg.	H. bog spavin.
B. splint.	F. thoroughpin.	I. poll evil.
C. ringbone.	G. curb.	
D. sidebone.		



Courtesy of the Live Stock Branch, Regina

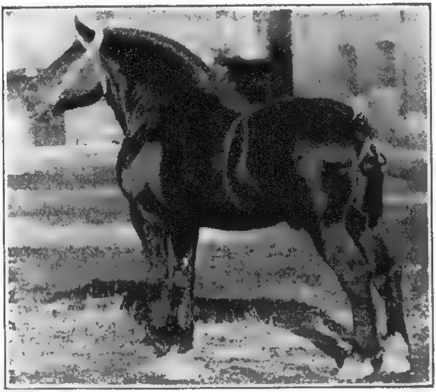
The grand champion Clydesdale stallion at the Royal Winter Fair, Toronto, and at the International Live Stock Exposition, Chicago, 1925.

Long, well-sprung ribs, forming a deep, wide middle, are essential. The hind-quarters must be wide and muscular. Also, the horse must have feet and legs that will not readily become unsound. The forearm and gaskin should be well muscled. The bones of the legs should be broad, flat, and clean—that is, with no softness or puffiness, especially at the joints. Long, sloping pasterns improve the action of the horse and the wearing qualities of his feet and legs. The feet should be broad, deep-walled, and waxy. The horse must have good action; that is, he must travel straight with a long, easy stride, lifting his feet up and down squarely, and flexing the knees and hocks well. Quality is also essential and is indicated by a clean-cut, alert appearance, silkiness of coat, and fineness and shape of bone.

Courtesy of the Live Stock Branch, Regina

The grand champion Shire stallion at the Royal Winter Fair, Toronto, and at the International Live Stock Exposition, Chicago, 1924.

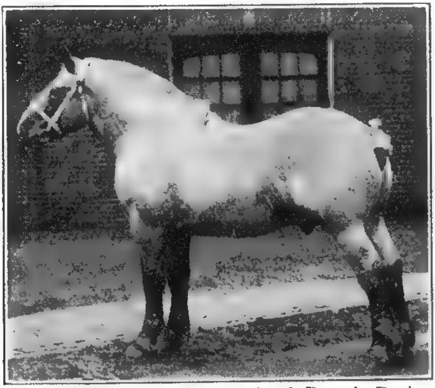
Breeds of Draft Horses.—The *Clydesdales* originated in the Clyde Valley, Scotland. In color they are most commonly bay or dark brown, with white feet and face. The legs are covered with long hair called feathering. The "Clydes" excel in action and in quality of bone.



Courtesy of the Live Stock Branch, Regina

A prize-winning Percheron stallion at the Royal Winter Fair, Toronto, and at the International Live Stock Exposition, Chicago, 1923.

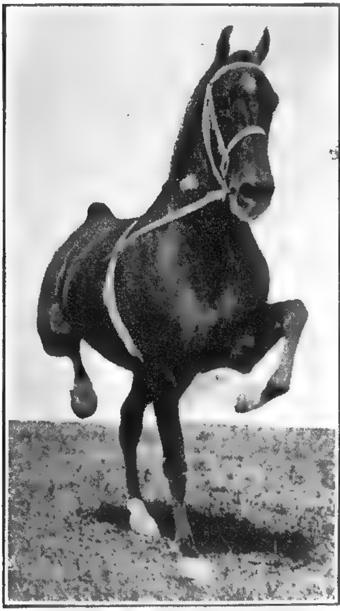
The *Shires.*—The history of the Shires traces back to the time of the Romans. Their home is in England, where they are used almost exclusively for draft purposes. They are the heaviest breed of horses. In appearance they resemble the Clydesdales, but they are much more massive, being noted for their size and strength.



Courtesy of the Live Stock Branch, Regina

The grand champion Belgian stallion at the Royal Winter Fair, Toronto, 1923, 1924, and 1926.

The *Percherons* originated in the province of La Perche, France. Blacks and greys are the most common. They are stoutly built, with wide, deep bodies. Their legs are clean, with no feathering. The Percherons are

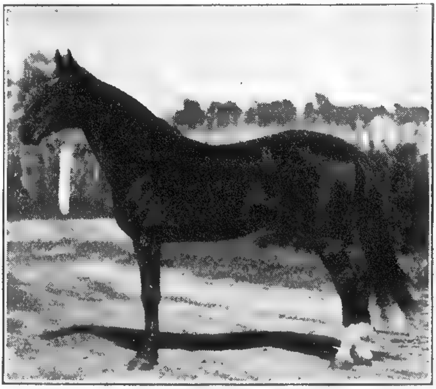


A prize-winning Hackney stallion.

usually quite docile and are popular as one of the best all-round breeds.

The *Belgians* were first bred in Belgium. In color they are chestnut, bay, brown, or roan. They are the most compact of draft horses. No other breed shows such development of body with respect to width and depth, especially in the chest. As a rule they are lower set and blockier than the Percherons, and are one of the most useful breeds of draft horses.

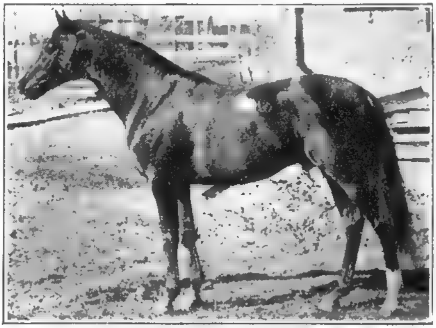
Heavy Harness Horses.—The *Hackneys* were developed in Great Britain as large driving or coach horses. They are big, broad, and low-set. In spite of their powerful build, their bodies are smooth and symmetrical. They are extreme in action, lifting their feet very high, with a long bold stride. Chestnuts are the most popular, although the Hackney may be bay, brown, or black.



A Standard Bred stallion.

Light Harness Horses.—The *American*

Trotters and Pacers or the *American Standard Breds* have been developed in America essentially as driving horses and racers. They are noted for their speed and endurance. In general they are slim and muscular, and their bodies are narrow but of great depth.



A prize-winning Thoroughbred stallion.

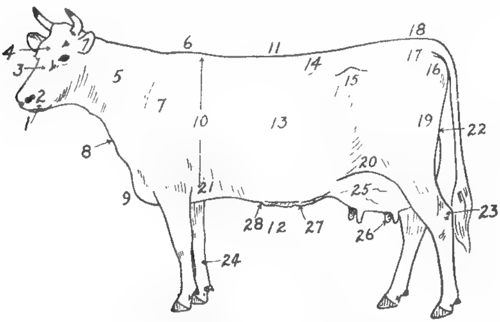
Saddle Horses. — The *Thoroughbreds* are a breed developed in England for racing under the saddle. They are tall, slim, and high spirited, with exceptional quality of structure and stamina. The Thoroughbreds are the fastest of all horses and are usually bay or brown in color.

Courtesy of the Live Stock Branch, Regina
A Saddle Horse, winner of many prizes in California.

The *Arabs* are the oldest breed of horses and are noted for their courage, quality, symmetry of form, and graceful action. They are the foundation of most of the other breeds of light horses, but as a breed are not important in America.

Types of Cattle.—Cattle are raised chiefly to produce meat and milk. It has been found that the type most

suitable for the production of meat will not produce a large quantity of milk. For this reason two types of cattle have been developed. The *dairy type* may be regarded solely as machines for the production of milk. They are lean and angular and altogether different from the *beef type*, which are thick, blocky animals, heavily covered with flesh. There are also *dual-purpose* cattle, which will produce a fair quantity of milk and at the same time possess good meat-producing qualities.



THE POINTS OF CATTLE

1. muzzle.
2. nostril.
3. face.
4. forehead.
5. neck.
6. withers or shoulder top.
7. shoulder.
8. dewlap.
9. chest, brisket.
10. heart-girth.
11. topline or back.
12. underline.
13. middle or barrel.
14. loin.
15. hook bones.
16. pin pones.
17. rump.
18. tail head.
19. thigh.
20. hind flank.
21. foreflank.
22. twist or escutcheon.
23. hock.
24. shank.

MAMMARY SYSTEM

25. udder.
26. teats.
27. milk veins.
28. milk wells.

When cattle are slaughtered, their hides are used for making leather. Buttons are manufactured from the bones and horns. The hoofs are used to produce glue. From the waste parts of the body a fertilizer is produced that is valuable to restore certain plant foods to the soil. Little, therefore, is wasted.

The Beef Type.—These cattle must be long, deep, wide, lowset, and blocky. A rectangular conformation is desirable. The back should be strong and straight, and the underline straight and parallel to the topline. A short, wide head with broad muzzle indicates feeding ability. The neck should be short and full and should blend well into a broad, compact shoulder. An animal with a strong con-

stitution must have a broad, deep chest and a large heart-girth. Ability to consume a large quantity of feed is indicated by long, well-sprung ribs, forming a deep, wide middle. The loin should be broad and thick. The hind-quarters should be fleshed well down to the hock, and should carry the width of the rest of the body well to the rear. In finished animals the whole body must be covered with a deep, uniform layer of flesh, especially over the back, loin, and hind-quarters, as these parts produce the highest-priced cuts of meat. The flesh should have a soft, mellow feeling, and a thin, pliable hide is desirable. The animal should have an appearance of quality as evidenced by fineness of head, bone, hair, and hide. Why are coarse-boned beef cattle objectionable?

The grand champion Shorthorn bull, Regina, 1916.

Courtesy of the Live Stock Branch, Regina

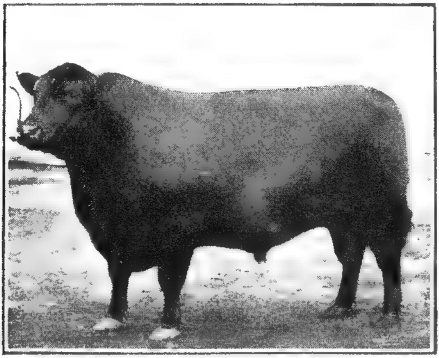
The grand champion Hereford bull on the Western Fair Circuit, 1924 and 1925, and at the Royal Winter Fair, Toronto, 1925.

Breeds of Beef Cattle. — The *Shorthorns* were developed in Northern England. In color they are red, white, or roan. They are the largest and one of the best all-round breeds, being long, deep, wide, lowset, and well developed in the hind-quarters. The Shorthorns are early maturing and easy to feed. From the beef breed have

been developed the *Polled Shorthorns,* to meet the demand for hornless cattle, and the *Milking Shorthorns.*

The *Herefords* originated in Herefordshire, England. They are sometimes called the "White Faces", and are marked with white on face, chest, and underline. The rest of the body is dark red or wine-colored. They are popular as a breed of early-maturing qualities and of great chest development, indicating vigor and ability to rough it in the open during the winter. There are also *Polled Herefords.*

The *Aberdeen Angus* are hornless black cattle. They are supposed to have originated from the wild cattle of North-eastern Scotland. While not as heavy as the Shorthorns or Herefords, they are superior for in-door feeding, for which purpose they are essentially fitted, being the smoothest and most evenly-fleshed of the beef breeds. The smoothness, early maturity, uniformity, and high dressing percentage of the "Doddies", as they are sometimes called, makes them popular for the production of high-quality meat, especially baby beef.



Courtesy of the Canadian Aberdeen Angus Association
The grand champion Aberdeen Angus bull at Toronto in 1922.

The *Galloways* originated in South-western Scotland. Like the Angus, they are black and hornless, but they are characteristically rougher and covered with long, thick, wavy hair. Their hides are often used in the manufacture of robes. They are noted for their ability to withstand hardship and cold, but are slow maturing and inclined to be

small. While not as popular as some other breeds, they are, nevertheless, easy feeders and dress out well, and are altogether a very desirable breed of beef cattle.

A Holstein-Friesian cow, the world's champion butter-producer from January to June, 1923. Record for 365 days, 30,866 pounds of milk and 1,681.25 pounds of butter. The cow is owned by the Dominion Government Experimental Farm, Agassiz, British Columbia.

The Dairy Type.—The type of cow associated with heavy milk production differs greatly from the beef type. The dairy cow is spare in flesh, angular, and wedge-shaped. There are three wedges, one from the front, one from the side, and one from the top. The head is longer than that of the beef breeds. A broad forehead, large, prominent eye, and broad muzzle are desirable. The neck is longer and thinner, and the shoulders are sharper. Because the production of milk is hard work, the dairy cow must be strong in constitution, as indicated by depth of chest and width between the front legs. The ribs should be long and well sprung, as the cow that produces large quantities of milk must be able to consume large amounts of feed. The

Courtesy of the Canadian Ayrshire Breeders' Association

A prize-winning imported Ayrshire cow. Notice the large winding milk-veins.

best udder is large, well formed, evenly balanced, attached high up behind, and carried well forward under the body. The milk veins, which pass along the under part of the cow's body and carry the blood from the udder to the heart, must be winding and large. A good flow of blood is essential, as the milk is produced from the blood. The milk wells, by which the milk veins enter the body, should be large, and it is better if there are more than one on each side of the body. A good dairy cow must also have dairy temperament—that is, she must have a refined, alert appearance with a clear, bright eye, indicating a highly developed, active nervous system.

The first-prize Guernsey cow at Waterloo, Iowa, 1925.

The Dairy Breeds.—The *Holstein-Friesians* are natives of the Province of Friesland, Holland. They are black and white in color, and are the largest of the dairy breeds. "Holsteins" are hardy, docile, and easily managed, and are the heaviest milk-producers, having records as high as 20,000 pounds or more per year, although their milk is not as rich in butter-fat as that of some of the

The grand champion Jersey cow at the Inter-State Fair, Iowa, 1925.

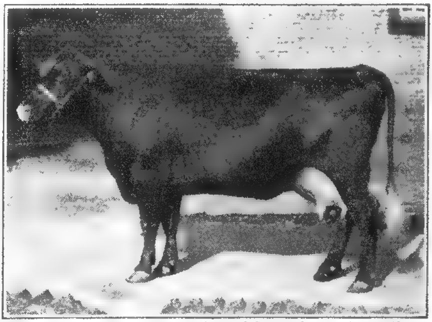
other breeds of dairy cattle. They are the most common dairy breed in Canada.

The *Ayrshires* originated in the Ayr Valley, Scotland. They are next in size to the "Holsteins" and are red and white in color. The prominent upright horn is one of their distinguishing characteristics. The Ayrshires tend to be less angular and more like the beef type than the other dairy breeds, but are good milk-producers.

The *Guernseys* were first bred in the Isle of Guernsey, one of the Channel Islands. They are fawn in color, with white markings. Next in size to the Ayrshire, they are splendid producers of a rich, yellow-colored milk, which yields a large percentage of butter-fat.

The *Jerseys* are a dark or grey-fawn-colored breed, developed in the Isle of Jersey, another of the Channel group. They are the smallest dairy breed, and, while not heavy milk-producers, their milk is very rich in butter-fat. The Jerseys are outstanding in dairy conformation and are essentially butter cows and not milk-producers.

The Dual Purpose Type.—Dual purpose cattle must possess bodies that conform very closely to the blocky rectangular build of the beef type; at the same time they must be capable of producing a good supply of milk. Where there is a willingness to be content without marked milk or meat producing ability but with a fair degree of both, there is certainly a place for the dual purpose cow. But in the breeding of this type



The grand champion aged Red Polled cow in milk at the International Live Stock Exposition, Chicago, 1924.

the result is usually a true dairy animal or a reversion to the beef type. Why?

The Dual Purpose Breeds.—The *Milking Shorthorns* are similar in color and other breed characteristics to the beef-type Shorthorns, but in body conformation they are between the lowset, thick beef type and the lean, angular dairy type. They have been developed from beef-type Shorthorn families and are good milk-producers.

The *Red Polled* are natives of England. They are hornless or polled, red in color, and present a high combination of the rectangular, deep beef conformation, with a good covering of flesh where the high-priced cuts of meat are produced, and ability to produce a good quantity of milk.

The Classification of Sheep.—The classification of sheep is based upon the length and fineness of the wool. There are three types, namely, the *short* or *fine woolled* type, the *medium woolled* or *down* type, and the *long* or *coarse woolled* type. The medium or down breeds are best for mutton production and have a lowset, rectangular body similar to the beef-type cattle.

The Fine Wool Breeds.—These sheep were raised formerly almost entirely for the wool which they produce.

The *Merinos* originated in Spain, and are the oldest breed of the fine woolled type. They have spiral horns, and over the neck and shoulders have heavy folds or wrinkles. The Merinos produce a large quantity of wool of very fine quality.

The *Delaine Merinos* have been developed in America. They are larger and smoother than the Merinos, and have a much better mutton carcass. There are no folds on the body, and the wool is somewhat coarser.

The *Rambouillets* were produced in France from Merino stock to meet the demand for a fine wool sheep with a better

mutton conformation. They are the largest of the fine wool breeds, and produce a fair mutton carcass. Females are hornless and rams may be hornless or have a large spiral horn. There are folds over the neck, and the fleece is from 10 to 15 pounds in weight. They are very popular in the United States, and are now coming into favor in Canada.

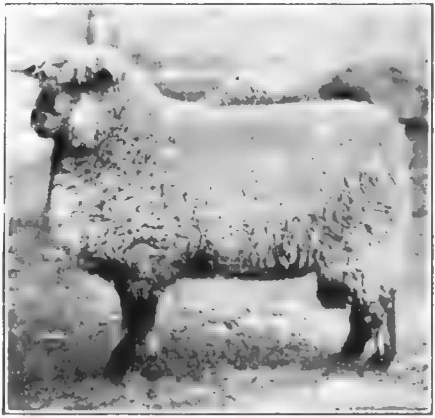

A champion Rambouillet ram.

The Medium Wool or Down Breeds.—Sheep are produced in Western Canada for both wool and mutton. The desired body conformation resembles that of beef cattle. The sheep should be rectangular, wide, deep, and lowset. The back should be strong and wide, and the underline straight and parallel to the topline. Strength of constitution is important, as indicated by width of chest and expanse of heart-girth. The best type of head is short and broad, with a strong muzzle, and a full, bright eye. The neck should be short and thick; the shoulders, wide and compact; and the middle, loin, and hind-quarters, broad and deep. A smooth, thick layer of flesh should cover the body, especially over the shoulder, back, loin, and hind-quarters. Why these parts particularly? A bulging leg of mutton is desirable. The fleece should be fine in quality, long, and dense enough to offset severe winter conditions. It is important that the wool have a close crimp (wave) and a bright lustrous appearance as indicated by an abundance of yolk (oil). When ready for market, a sheep in good condition should weigh about 200 pounds. The best sheep for our con-

ditions is an early-maturing, blocky, lowset, vigorous, close-woolled type, as best represented by the down breeds.

A champion Shropshire ram at the Minnesota State Fair, 1924.

The *Southdown* is a breed of English origin. They are hornless, and their faces and legs are greyish brown. Their skin is quite pink. In size they are the smallest of the down breeds, but are a splendid mutton sheep. On account of their compact conformation, smoothness, and early-maturing qualities, they may be said to represent in sheep what the Aberdeen Angus stands for in beef cattle. Their fleece is about 2½ inches in length.



Courtesy of the Live Stock Branch, Regina

A prize-winning Oxford ram.

The *Shropshires* are another hornless breed originating in England. Their faces and legs are dark brown, and both legs and faces are covered with wool. The "Shrops" are of good size, and their wool is about 2½ inches long. Their lowset, compact form and their hardiness make them popular in Western Canada.

The *Oxfords* were developed in England. They are hornless, and are by far the largest down breed. Their faces, which are dark brown, are not woolled as the Shropshire. A distinguishing characteristic is a prominent forelock or cap of wool. The fleece is longer, but a little coarser. They are blocky and square, well suited to our conditions, and are, therefore, quite popular.

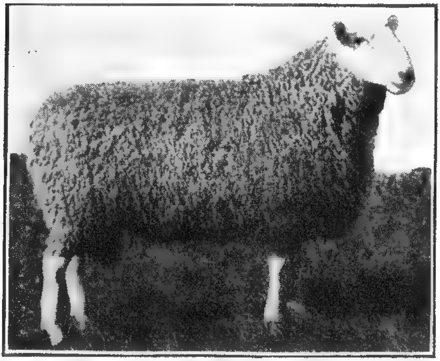

A champion Hampshire ram at the Illinois State Fair, 1924.

The *Hampshires* are also natives of England. They are second in size to and often confused with the Oxfords, but they are easily distinguished by their Roman noses and very dark feet and legs. They are quick maturing, and a good mutton sheep. Their fleece is similar in length to that of the Shropshires.


Courtesy of the Live Stock Branch, Regina
A champion Suffolk ram at the Royal Winter Fair, Toronto, 1924.

The *Suffolks* were first bred in England. They are good mutton sheep, and have black, bare faces and legs. Their fleece is fairly light, weighing from 6 to 9 pounds. They are next in size to the Hampshires.

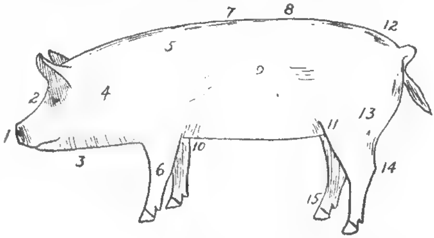
The *Horned Dorsets* are from Southern England. They have horns curving downwards and white faces and legs. Their fleece will weigh from 6 to 9 pounds, and they are considered a fair mutton sheep.



Courtesy of the Live Stock Branch, Regina
The grand champion Leicester ram at the Regina Winter Fair, 1923.

The Long Wool Breeds.—The *Leicesters* are one of the oldest breeds of sheep. They originated in England, and are fair-sized, very stylish in appearance, but inclined to lack in hardiness. The fleece is about 6 inches in length, and open but of good crimp, weighing on the average 8 to 9 pounds. Their faces and legs are bare and white. The Leicester is one of the best of the long-wool breeds, but is not popular in Western Canada because of its open fleece.

The Karakul Sheep.—This class of sheep is the source of Persian lamb fur, for which purpose they are raised exclusively. To produce the best quality pelt the lambs are slaughtered when a few days old. They are natives of Bokhara, Asia. The Karakuls are medium-sized, with drooping ears and broad tails. The wool is long, coarse, and hairlike in appearance and grey to brown in color.

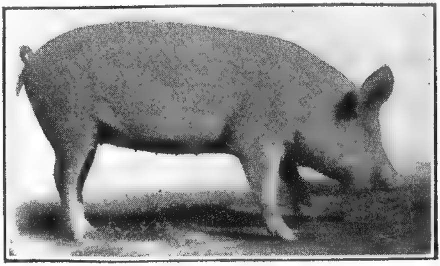


THE POINTS OF A HOG

1. snout.	6. foreleg.	11. rear flank.
2. face.	7. back.	12. rump.
3. jowl.	8. loin.	13. ham.
4. neck.	9. side.	14. hock.
5. shoulder.	10. foreflank.	15. pastern.

Their feet and legs are black. There are now a few karakul ranches in Canada. Persian lamb fur is in great demand.

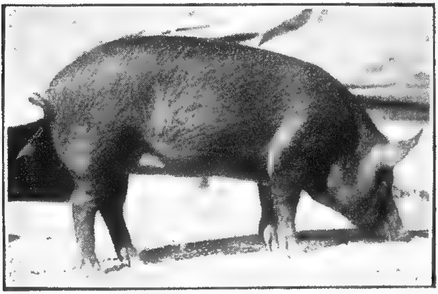
Types of Swine.—There are two types of hogs—the *bacon type*, developed to produce bacon and the *lard type*, designed to produce fat or lard.



Courtesy of the Live Stock Branch, Regina

A prize-winning Yorkshire sow, imported from Great Britain in 1923 by the Saskatchewan Swine Breeders' Association.

The Bacon Type.—Bacon is produced from the back and sides of the body, so these parts must be of great length. The desired type of hog is long of body and of medium depth. The jowls should be light and free from wrinkles; the shoulder, close and smooth; the back, well arched, the sides dropping straight from the back; the underline, straight; and the hams, full but not heavy or wrinkled. Hogs kept for breeding purposes must show strength of constitution and good quality of bone. If you were considering hogs finished for market, would you pay a great deal of attention to strength of constitution? Give a reason for your answer.



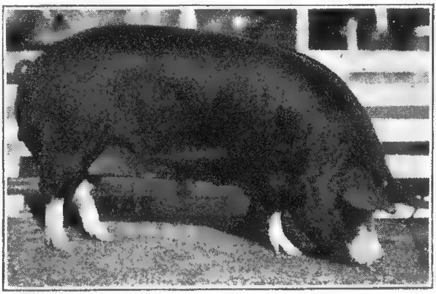
A junior champion Tamworth sow.

Market Standards.—In selling hogs the highest prices are received for "selects". A "select" is a hog of correct bacon type, as described above, and weighing from 180 to 230 pounds on the farm or from

170 to 220 pounds when unloaded from the cars at the stockyards. Such a hog produces the best bacon. Most of the hogs produced in Canada are exported to Great Britain as *Wiltshire sides.* A Wiltshire side is one-half of a pork carcass without the head and shanks. Great Britain is one of the world's best markets for high-quality bacon. To produce bacon of the required British standard a Wiltshire side must weigh between 60 and 65 pounds, possess great length, and have the fat and lean well balanced. Denmark exports large quantities of bacon to Great Britain, and to meet this competition, which is very keen indeed, Canadian bacon must be carefully selected to meet the standard.

The grand champion Hampshire sow at the Indiana State Fair, 1925.

Breeds of Bacon Hogs. — The *Large Yorkshires* are a white breed from Yorkshire, England. They are the largest of the bacon type and possess remarkable length of body. (See page 215.)



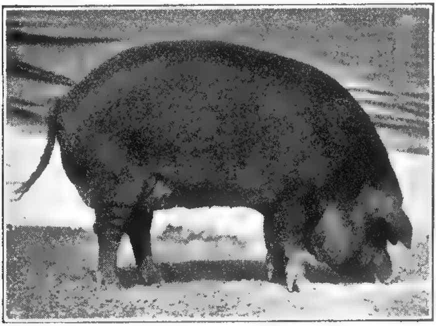
The grand champion Berkshire sow at the International Live Stock Exposition, Chicago, 1924.

The *Tamworths* are another breed of English origin. They are a golden red in color and considered to be a very desirable breed for bacon production.

The *Hampshires* were developed in Kentucky. This breed is somewhat heavier than the other bacon hogs but is quite smooth and a good bacon type. They are black in color with a white belt around the body just behind the shoulders.

The grand champion Poland China sow at the South Dakota State Fair, 1925.

The Lard Type.—This type is a hog with a short, thick, lowset, heavy body. Jowls are heavy and full; neck, thick; shoulders, broad and heavy; back, thick, fat, and large; and hams, thick. While possessing great width and depth, hogs of this class lack length, smoothness, and often strength of bone and general quality. This type is not as popular in Canada as the bacon type.



A prize-winning Duroc Jersey sow at the National Swine Show, United States, 1924.

Breeds of the Lard Type.—The *Berkshires* are from Berkshire, England, and are noted for their smoothness and quality. They are black with six white points, namely, face, four feet, and tip of the tail. Their heads are deeply dished, that is, the snout is sharply turned up; and their ears are erect. These two characteristics help to distinguish them from another breed of markings of very similar color.

The Berkshires are very popular in Canada, where they have been developed more along bacon type than strictly lard type. The modern "Berks" resemble the Yorkshires and Tamworths in conformation.

The *Poland Chinas* are from Ohio. They are large in size and black in color, with six white points like the Berkshires, but distinguished from the "Berks" by their greater size, straight face, and drooping ears. The Poland Chinas are exceptionally broad, lowset, and high in quality, but are often very fat.

The grand champion Chester White sow at the Indiana State Fair, 1925.

The *Duroc Jerseys* are natives of New York and New Jersey. They are much like the Poland Chinas in type, and are cherry red in color.

The *Chester Whites* are hogs of American origin. They are quite large, and are pure white in color. Like the Berkshire hogs, they have been developed in Canada more along the bacon type than the lard type.

Exercises.—(1) Make a summary of the characteristics of each type of horses, cattle, sheep, and swine, under the following headings: general appearance, head, neck, shoulder, chest and heart-girth, middle, hind-quarters, quality, finish or condition, and special characteristics such as the feet and legs of horses, mammary development of dairy cows, wool of sheep, etc.

(2) Identify the breeds in your district, and as a project find out the approximate number of each breed.

(3) Distinguish between the terms: cattle and beef, calves and veal, sheep and mutton, hogs and pork.

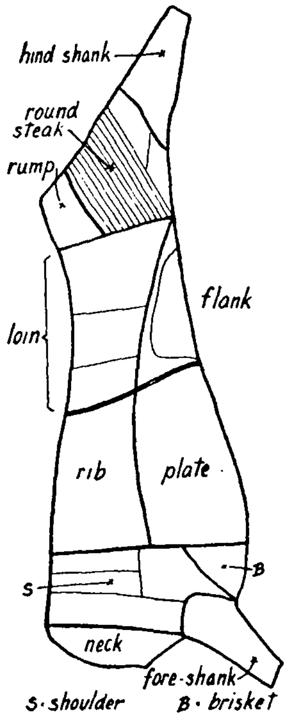
(4) Draw charts to represent carcasses of beef, mutton, and pork. Ask a butcher the price of the various cuts. Locate the cuts on your chart and mark in the prices. What parts of the living animals do the prices of the cuts indicate should be particularly well developed?

(5) Which breed or breeds of horses, beef cattle, dairy cattle, sheep, and swine do you consider to be most suitable for the average farm in Western Canada? Give reasons.

(6) Which breed of dairy cattle would you recommend for straight dairy farming? State reasons for your recommendation.

Projects.—(1) Arrange to visit fairs where live stock are being exhibited. Watch the judges at work.

(2) Study the history of the various breeds. Become familiar with the names and work of the men who developed them. Read Wade Toole's *Book of Live Stock* published by the Musson Book Company, Toronto, and other references.



A side of beef, showing the method of cutting up. (Draw.)

Suggestion for Teachers.—Make a collection from the farm magazines, etc., of pictures of each of the various breeds. The collection should include more than one example of each breed and several group pictures. Remove all names. Ask the students to identify the breed in each illustration and state the characteristic or characteristics that disclose the identity of the breed in each case.

CHAPTER XII

THE FEEDING AND CARE OF LIVE STOCK

The problems of animal hygiene and nutrition must be carefully studied by the farmer who would make the greatest success of feeding live stock. Profits depend directly upon the cost and suitability of the feeds used and upon the clean healthful surroundings in which the stock are kept.

Exercises.—To learn something of the constituents of plants secure the following material: common seeds such as wheat, oats, barley, corn, peas, beans, etc., and the stems and leaves of grasses, grains, corn, or alfalfa.

(1) Place a small quantity of finely cut-up plant material in a dish. Weigh accurately. Heat in an oven at a temperature of 212° F. for several hours, cool, then weigh again. The loss in weight will indicate the amount of *water* originally contained in the plant. Conduct this experiment with green plants, dry hay, mature seeds, and compare. The material left when the water has been driven off is called *dry matter.*

(2) Place a small amount of plant material in a crucible. Heat strongly until combustion is complete. The material that remains is *ash* or *mineral matter.*

(3) Boil some stems and leaves alternately in a weak acid and a weak alkali (sodium hydroxide). Each time wash out the dissolved substances. The material remaining is the *fibre* or *cellulose* which forms the hard, woody skeleton of a plant.

(4) Grind up some wheat kernels or other seeds. Place in a test-tube to a depth of about 1 inch. Add $\frac{1}{3}$ of a test-tube of water. Shake well. Boil vigorously for several minutes. Cool by holding under a tap or in cold water. Add a few drops of strong nitric acid. Boil again and cool. If a yellow color develops, a substance called ***protein*** is indicated. Now add a few drops of ammonium hydroxide, and a deep orange color further proves the presence of protein.

(5) Repeat the foregoing exercise but add a few drops of iodine solution instead of nitric acid. A deep blue color indicates *starch.*

(6) Repeat the first part of Exercise No. 4, this time adding Fehling's solution. When heated, a dull reddish-brown color indicates the presence of *sugar*. If there is no reaction from wheat, try peas, sweet corn, or beans. Fehling's solution is produced as follows: dissolve 3.5 grams of copper sulphate in 50 c.c. of water, label this solution *A*; dissolve 17.5 grams of Rochelle salts in 50 c.c. of a 10 per cent solution of sodium hydroxide, label this solution *B*. When ready to use, mix solutions *A* and *B* in equal proportions. Solutions *A* and *B* may be purchased at a drug store.

(7) Place a few grains of starch in a dry test-tube; heat carefully until the starch is completely charred or blackened. Observe the moisture that collects in the cool part of the test-tube. The black substance left in the bottom of the test-tube is *carbon*, and the water, we know, is composed of *hydrogen* and *oxygen*. What is your conclusion as to the composition of starch?

(8) Place some crushed sunflower seeds, flax seed, etc., with the shells removed, upon a piece of white paper. Heat gently over a flame. Observe a grease spot on the paper. This indicates *oil* or *fat* in the plant.

The Composition of Plants.—From the foregoing experiments we see that the composition of plants is as follows:

Plant { *Water*—from a very small amount in dry seeds to 90 or 95 per cent in potatoes, turnips, etc.
Dry Matter—all materials in the plant except the water. }

(*a*) *Fibre*—the hard, woody skeleton of the plant.

(*b*) *Ash* or *Mineral Matter*—calcium (lime), iron, magnesium, etc.

(*c*) *Carbohydrates*—these are the starches and sugars of the plant, and are called carbohydrates because they are composed of carbon, hydrogen, and oxygen, the hydrogen and oxygen being in the same proportion as in water.

(*d*) *Proteins*—when nitrogen is combined with **carbohydrates**, proteins are produced.

(*e*) *Fats*—like the carbohydrates, are composed of carbon, hydrogen, and oxygen. (See page 53.)

The Animal Body.—From a study of the following table it will be seen that the bodies of animals are composed of the same materials as plant bodies.

Percentage Composition of the Entire Bodies of Farm Animals*
(fasted live weight)

Description of Animal	Protein	Fat	Mineral Matter	Total Dry Substance	Water	Contents of Stomach and Intestines (moist state)
Fat steer...	14.5	30.1	3.92	48.5	45.5	5.98
Fat sheep..	12.2	35.6	2.81	50.6	43.4	6.02
Fat pig.....	10.9	42.2	1.65	54.7	41.3	3.97

The Function of Plant Constituents in Feeds.—Each plant constituent, when consumed, has a special part to perform in the life processes of the animal body.

Fibre is indigestible and is useful to *give bulk* or volume to a feed and to help fill up the animal.

Proteins are necessary for the *growth* and *repair* of *muscles, cartilages, nerves, brain, internal organs,* such as the *heart, lungs, etc.*, and *hide, hair, wool, feathers, hoofs, nails,* and *horns*. It is also essential for *milk* and *egg* production.

Carbohydrates supply *heat* and *energy* to the animal body and materials for the production of fatty tissue.

Fats are also sources of *heat* and *energy* and fat-producing materials.

Mineral matter is required to furnish material for *bone building.*

The problem of feeding animals is to select and mix together such plants or parts of plants as will most efficiently and economically supply them with the materials required for the maintenance of their bodies, work, or the production of milk or eggs.

*Data by Lawes and Gilbert, Rothamsted Experimental Station, England.

Digestion.—An animal, when provided with a suitable selection of feeds, breaks them up by the processes of digestion and employs the most useful parts to build up the tissues of its body, to keep itself warm, and to produce energy for work. It will be understood how important it is to supply the live stock of the farm with feeds that are suitable.

Digestible Nutrients.—*Nutrient* is the name given to any food constituent, such as protein, carbohydrate, or fat,

Courtesy of The Grain Growers' Guide, Ltd.

Harvesting mangels to be used for feeding live stock.

which may be used to nourish the animal body. Not all nutrients are digestible; *digestible nutrients* are those that can be digested by animals and taken into their bodies. The figures given on the following page have been selected from a much longer table in *Feeds and Feeding* by Henry and Morrison.

Exercise.—Make a study of some of the common feeds used in Western Canada, using Table A as follows: Compare the amount of protein in the feed with the amount of combined carbohydrates and fat. This comparison is indicated in the table by the Nutritive Ratio. For example, buttermilk is rich in protein because its Nutritive Ratio

Table A—Chemical Composition of Some Common Feed Plants

(Pounds of nutrients in 100 pounds of feed)

Feed	Dry Matter	Digestible Protein	Digestible Carbo-hydrates	Digestible Fat	Total Digestible Nutrients	Nutritive Ratio
Alfalfa	91.4	10.6	39.0	0.9	51.6	1: 3.9
Brome Grass (smooth)	91.5	5.0	44.2	0.9	51.2	1: 9.2
Timothy Hay	88.4	3.0	42.8	1.2	48.5	1:15.2
Prairie Hay	93.5	4.0	41.4	1.1	47.9	1:11.0
Oat Straw	88.5	1.0	42.6	0.9	45.6	1:44.6
Corn Silage	21.0	1.0	11.4	0.4	13.3	1:12.3
Turnips	9.5	1.0	6.0	0.2	7.4	1: 6.4
Corn (grain)	89.5	7.5	67.8	4.6	85.7	1:10.4
Barley	90.7	9.0	66.8	1.6	79.4	1: 7.8
Oats	90.8	9.7	52.1	3.8	70.4	1: 6.3
Wheat	89.8	9.2	67.5	1.5	80.1	1: 7.7
Shorts	89.5	13.4	46.2	4.3	69.3	1: 4.2
Bran	89.9	12.5	41.6	3.0	60.9	1: 3.9
Oil Cake (old process)	90.9	30.2	32.6	6.7	77.9	1: 1.6
Skim Milk (centrifugal)	9.9	3.6	5.1	0.2	9.1	1: 1.5
Buttermilk	9.4	3.4	4.9	0.1	8.4	1: 1.5

is 1:1.5, that is 1 pound of protein to 1.5 pounds of carbohydrates and fat. Feeds whose nutritive ratio is less than 1.6 are considered to be rich in protein. Those with a nutritive ratio of more than 1.6 are low in protein and rich in carbohydrates and fats.

Concentrates.—Concentrates are feeds low in fibre and rich in digestible matter.

Corn is an easily digested, palatable feed much used for fattening cattle and hogs. Why is corn valuable for this purpose? Corn is not suitable for feeding young animals, as it is low in mineral matter. Is there any other growth-producing nutrient lacking?

Barley is used perhaps more than any other grain in Western Canada for fattening live stock. Why?

Oats are well balanced and, as a single grain, are the best for all kinds of live stock. Oats are used more than any other grain for horses. What is meant by saying that oats are well balanced?

Bran is the outer covering of the wheat kernel. It is quite bulky, and more suitable for older animals. Bran is used extensively for dairy cattle. Why? It is also used a great deal for horses and gives them a fat, well-fed appearance and a very glossy coat. What is there in bran to have this effect upon a horse?

Shorts or *Middlings* are found between the outer layer or bran and the starchy part of wheat. They are valuable for feeding young pigs and dairy cattle. What makes them valuable for this purpose?

Oil Cake or *Linseed Meal* is the residue of the flax seed after the oil has been extracted. When not too expensive, it is fed in limited amounts to dairy cattle, fattening cattle, horses, lambs, and pigs. Explain in what way oil cake is useful for each of the above-mentioned farm animals. It is often used as a tonic to keep live stock in a good state of health.

Skim Milk and *Buttermilk* are both high in ash, and therefore valuable for calves and young pigs. What other nutrient are they rich in that makes them important in growth-producing rations?

Roughages for Feed.—Roughages are feeds high in fibre and low in digestible matter.

Legumes such as alfalfa, clover, etc., are valuable muscle and tissue builders, and especially useful for growing animals and dairy cows. Besides being high in mineral content, what other constituent are they rich in which makes them suitable for the above uses?

Corn.—The leaves and stalks of the entire corn plant form one of the most useful roughages. It is best stored as *silage*, in which state it supplies a very palatable, succulent feed, high in nutritive

value and easily digested. Silage is especially good for either beef or dairy cattle. Why?

Grasses are usually fed in the dried or cured state as *hay*. When grass or other green crop is cut and fed fresh, it is known as a *soiling crop*. They are relatively low in protein except when green and just before flowering time. Timothy is the best hay for horses. Why is too much hay not desirable for dairy cattle?

Courtesy of The Grain Growers' Guide, Ltd.

Two commonly grown types of millet. The millets are annual grasses that in Western Canada are grown only for feeding live stock.

Sunflowers have been found to be equal in food value to corn, and are favored by many because they will grow better than corn in some localities. But they cannot be used except as silage, and are not recommended except where corn cannot be grown.

Oat Straw.—Often, when hay or other roughage is scarce, straw may be used to replace them in rations for beef cattle or horses not working. It is most valuable when the grain has been cut slightly green, as it then contains more food value and is better liked by the stock. Why is straw not suitable for rations for dairy cows in milk or for young animals?

Turnips and other root crops, such as *mangels*, *beets*, etc., are a very succulent (juicy) feed useful for sheep or beef cattle, but not often for dairy cattle as they are liable to cause an unpleasant flavor in the milk.

The Silo and Silage.—The silo is usually tall and cylindrical in shape. Its walls, constructed of wood, brick, or cement, must be vertical, smooth inside, strong, and air-tight. The entire plants of the crops used, corn,

sunflowers, oats mixed with peas, etc., are first finely cut up, and then thoroughly tramped, to pack them tightly, as the silo is being filled. The silo must be built at least twice as high as its diameter, so that the silage will be deep and the upper layers will exert great pressure upon the silage below. The effect of this packing is to exclude the air from the material in the silo and thus preserve it for many months. Frequently, when the crop has become too mature or dry, moisture is added as the silo is filled. In this air-tight, moist condition fermentation is set up, and the silage becomes acid in flavor and very palatable to the live stock, which consume it in large quantities.


A silo on a prairie farm.

The chief advantage of a silo is that it preserves the silage in such a condition that it provides a splendid substitute for pasture or green feed during the months of drought or winter. The silo is the most economical means of preserving feed, there being less waste in this method than in any other. Being succulent and palatable, silage encourages a large flow of milk when fed to dairy cattle. It is not of much value as a feed for hogs.

The Pit or Trench Silo.—On account of the expense of constructing the tall upright silo, many are now built below the ground. The pit silo should be lined with cement to prevent loss of succulence, but good silage may be made without this feature. This type of silo has proved quite successful, its greatest disadvantage being the difficulty of removing the heavy silage from the pit.

Selecting a Ration.—*A ration* is the amount of feed supplied to an animal in a day. In arranging a combination of the various feeds for an animal's daily allowance, it is essential to study carefully the composition, palatability, concentration, bulk, and succulence of each feed under consideration. Growing animals require feeds rich in *vitamines*. These growth-promoting factors are found in the fat of milk, the thin leaves of plants, etc. The cost of the ration must receive attention. It is frequently necessary to substitute cheaper feeds for those being used. Underfeeding also reduces profits.

Maintenance Rations.—Before an animal can gain in weight or perform work, it must first secure from its ration materials for the upkeep and work of its body, such as moving about, breathing, digestion, etc. For example, a horse uses two-thirds of the average ration for digestion and bodily maintenance, leaving only one-third for external work. A *maintenance ration* is the amount of feed required per day to maintain an animal at rest so that it neither gains nor loses in weight. Such rations are frequently fed to live stock on the farm during the winter when no work is required of them.

Nutritive Ratios.—When animals are being fed for work, milk or egg production, or fattening purposes, they require much more than for maintenance. The correct amount and proportion of the various nutrients necessary are found by calculating the nutritive ratio, that is, the proportion of digestible protein to the combined digestible carbohydrates and fat. The method used is to multiply the digestible fat by 2.25 (the fat contains 2.25 times the heat and energy that carbohydrates do), add the result to the digestible carbohydrates, and divide the sum by the total digestible protein.

For example: a horse weighing 1,600 pounds at hard work would require 19 pounds of prairie hay and 18 pounds

of oats daily. From Table A on page 194, it is found that in 19 pounds of prairie hay there are $\frac{4.0}{100} \times 19 = .760$ pounds of protein, $\frac{41.4}{100} \times 19 = 7.866$ pounds of carbohydrates, and $\frac{1.1}{100} \times 19 = .209$ pounds of fat. By the same method the amounts of the three nutrients in the oats may be calculated. Add these together and arrange as follows:

	Protein	Carbohydrates	Fat
Prairie Hay, 19 lb.	.760 lb.	7.866 lb.	.209 lb.
Oats, 18 lb.	1.746 lb.	9.378 lb.	.684 lb.
Total..........	2.506 lb.	17.244 lb.	.893 lb.

Multiply the fat by 2.25, and the product is $.893 \times 2.25 = 2.00925$. Add this to the carbohydrates, and the sum is 19.25325. Divide this sum by the protein, $19.25325 \div 2.506 = 7.68$. The nutritive ratio of this ration is therefore 1:7.68, that is 1 part of protein to 7.68 parts of carbohydrates and fat.

Different kinds of animals require rations of different nutritive ratios. A nutritive ratio that is relatively rich in protein and low in carbohydrates and fat is called *narrow*, and one high in carbohydrates and fat but low in protein is called *wide*.

When to Use a Wide or Narrow Ratio.—Exercises.—(1) The following experiment was conducted at the Maine Experimental Station. The purpose was to determine whether wide or narrow rations were most suitable for feeding beef cattle. Four animals, 5 to 7 months old, were used. Two were fed for 17 months, one on a narrow ration and the other on a wide ration. The other two animals were fed for 27 months, one on a wide ration and the other on a narrow ration. The following results were observed:

Animals	Total Gain in Weight	Digestible Nutrients consumed per 100 lb. Gain
Animals fed 17 months		
On a narrow ration 1:5.2.	737 lb.	495 lb.
On a wide ration 1:9.7.	552 lb.	686 lb.
Animals fed 27 months		
On a narrow ration......	962 lb.	773 lb.
On a wide ration........	1005 lb.	708 lb.

(*a*) Of the first pair which animal gained the most in weight?

(*b*) In this lot which animal required the least feed to produce 100 pounds gain in weight?

(*c*) Of the second pair which animal put on the most weight?

(*d*) Which of the two animals in the second lot consumed the least feed per 100 pounds gain in weight?

(*e*) The first pair are still young. Their increase in weight is due to growth. What is your conclusion as to the value of a wide or narrow nutritive ratio for feeding young animals. Give reasons.

(*f*) The other animals fed for 27 months are practically full grown, and their increase in weight is mostly fat. What conclusion are you able to make as to the value of wide or narrow nutritive ratios for fattening mature beef cattle? Give reasons.

(2) Below is an experiment conducted at the Wisconsin Experimental Station to determine the effect upon pigs of rations rich in proteins and ash compared with corn alone.

Feed	Average Daily Gain in Weight	Live Weight at End of Experiment	Dressed Carcass per 100 Weight	Strength of Thigh Bone (pounds live weight)
Lot 1. Milk, shorts, blood (all rich in protein and ash)...	1.0 lb.	223 lb.	81.2%	503 lb.
Lot 2. Corn.......	0.7 lb.	187 lb.	80.2%	380 lb.

(a) Which lot of pigs gained the most in weight per day? State the ration used in each case. Which ration will have the narrowest nutritive ratio?

(b) Which lot weighed the most at the completion of the experiment?

(c) Which lot, when slaughtered, dressed out with the highest percentage?

(d) Which lot had the strongest bones?

(e) What is your conclusion as to the value of wide or narrow nutritive ratios for young animals?

(f) What two nutrients are lacking in the corn that are essential to growth and bone-building? State the purposes of each nutrient.

It has been found by such experiments as the foregoing that young animals and dairy cows require a fairly narrow nutritive ratio for growth or milk production. Fattening cattle or working horses require a fairly wide nutritive ratio for fat or energy.

Balanced Rations.—Feeding Standards.—A *balanced ration* is a mixture of feeds that will, without waste, meet the needs of an animal's body for twenty-four hours. Such a ration will return the greatest profit. It is calculated by comparing it with a standard ration. There have been a number of *feeding standards* proposed and used. The most recent and practical is *The Modified Wolff-Lehmann* or *The Morrison Standard.* (See page 202.)

The Method of Calculating a Balanced Ration for a Cow.—To balance a ration for a 1200-pound cow producing 30 pounds of 3.5 per cent milk per day, using prairie hay, corn, silage, oat chop, and oil cake:

The first step is to determine the standard requirements for a cow of the foregoing description. From the standard, Table B, it is found that a 1000-pound cow requires 0.700 pounds of digestible protein and 7.925 pounds of total nutrients per day for maintenance. A 1200-pound cow would therefore need $\frac{0.700}{1000} \times 1200 = .84$ pounds of protein

Table B.—The Morrison Standards for Feeding Farm Animals*
per day per 1000 lb. live weight

Animal	Dry Matter lb.	Digestible Protein lb.	Total Digestible Nutrients lb.	Nutritive Ratio 1:
Dairy cows				
For maintenance of 1000 lb. cow......		0.700	7.925	
To maintenance allowance add				
For each lb. of 2.5 per ct. milk.......		0.045–0.053	0.230–0.256	
For each lb. of 3.0 per ct. milk.......		0.047–0.057	0.257–0.286	
For each lb. of 3.5 per ct. milk.......		0.049–0.061	0.284–0.316	
For each lb. of 4.0 per ct. milk.......		0.054–0.065	0.311–0.346	
For each lb. of 5.0 per ct. milk.......		0.060–0.073	0.362–0.402	6.0–7.0
Fattening 2-year-old steers				
First 40–60 days....	22.0–25.0	1.8–2.1	16.5–18.5	7.0–8.0
Second 40-60 days...	20.0–23.0	1.8–2.0	16.0–18.0	7.0–8.0
Third 40-60 days....	18.0–21.0	1.7–1.9	15.5–17.5	7.0–8.0
Horses				
At light work.......	15.0–20.0	1.0–1.2	9.0–11.0	8.0–8.5
At heavy work......	18.0–22.0	1.5–1.8	13.0–15.0	7.6–8.1
Fattening lambs				
Weight 50-70 lb.....	27.0–30.0	2.7–3.0	19.0–22.0	6.0–6.7
Weight 70-90 lb.....	28.0–31.0	2.5–2.8	20.0–23.0	6.7–7.2
Weight 90-110 lb....	27.0–31.0	2.3–2.5	19.0–23.0	7.0–8.0
Fattening pigs				
Weight 50-100 lb....	37.0–40.8	5.5–6.0	32.9–36.4	5.0–5.6
Weight 100-150 lb...	32.4–35.8	4.4–4.9	28.8–31.9	5.5–6.2
Weight 150-200 lb...	29.0–32.0	3.5–3.9	25.8–28.5	6.2–7.0

*From *Feeds and Feeding* by Henry and Morrison.

and $\frac{7.925}{1000} \times 1200 = 9.51$ pounds of total nutrients. To these figures must be added the requirements for the milk produced. The standard allowance for each pound of 3.5 per cent milk is from 0.049 to 0.061 pounds of protein and from 0.284 to 0.316 pounds of total nutrients. For 30 pounds of milk the allowance would be 0.049×30 to $0.061 \times 30 = 1.47$ to 1.83 pounds of protein and 0.284×30 to $0.316 \times 30 = 8.52$ to 9.48 pounds of total nutrients. To determine the full daily allowance required, the allowance for maintenance and for milk production must be added together as follows:

	Digestible Protein	Total Digestible Nutrients
For maintenance..............	0.84 lb.	9.51 lb.
For milk produced............	1.47–1.83 lb.	8.52–9.48 lb.
Total for cow.................	2.31–2.67 lb.	18.03–18.99 lb.

The second step is to make up a ration from the feeds given and determine whether or not it supplies protein, etc., within the limits of the standard. This calculation is made by the use of Table A, page 194, in the same manner as amounts of protein, carbohydrates, and fat were determined in working out nutritive ratios, page 198. Starting with 10 pounds of prairie hay, 30 pounds of silage, 9 pounds of oat chop, and 1 pound of oil cake, calculate the total pounds of protein and total nutrients contained in this *trial ration.* From Table A it is found that 100 pounds of prairie hay contain 4.0 pounds of protein—therefore 10 pounds will contain $\frac{4.0}{100} \times 10 = .40$ lb. By the same procedure the total nutrients in the hay and the protein and the total nutrients in the other feeds of the trial ration may be calculated. Arrange your figures in a table as follows:

First Trial Ration	Digestible Protein	Total Digestible Nutrients	Nutritive Ratio
Prairie hay, 10 lb.....	.40 lb.	4.79 lb.	
Silage, 30 lb.....	.30 lb.	3.99 lb.	
Oat chop, 9 lb.....	.873 lb.	6.336 lb.	
Oil cake, 1 lb.....	.302 lb.	.779 lb.	
Total........	1.875 lb.	15.895 lb.	1: 7.47
Morrison Standard ...	2.31–2.67 lb.	18.03–18.99 lb.	1: 6.0–7.0

Placing the standard requirements after the total in each column, it will be seen at a glance that the foregoing ration is low both in digestible protein and in total digestible nutrients.

The third step is to make adjustments or additions to the trial ration in order to increase the constituents in which it is low. This could be done most easily, in this case, by increasing the amount of oil cake used; but, on account of its cost, 2 pounds of oil cake is the maximum amount recommended for dairy cattle. Therefore, try 2 pounds of oil cake and 12 pounds of oat chop. The protein and total nutrients of *the second trial ration* are calculated and arranged as before.

Second Trial Ration	Digestible Protein	Total Digestible Nutrients	Nutritive Ratio
Prairie hay, 10 lb.....	40 lb.	4.79 lb.	
Silage, 30 lb.....	.30 lb.	3.99 lb.	
Oat chop, 12 lb....	1.164 lb.	8.448 lb.	
Oil cake, 2 lb.....	.604 lb.	1.558 lb.	
Total........	2.468 lb.	18.786 lb.	1: 6.6
Morrison Standard ...	2.31–2.67 lb.	18.03–18.99 lb.	1: 6.0–7.0

The adjusted ration contains amounts of digestible protein and total digestible nutrients within the limits set by the standard and is, therefore, balanced. If it had been found that the second trial ration was not balanced, a *third trial ration* would have been necessary.

Calculating Balanced Rations for Other Farm Animals.—The method followed is identical to the foregoing outline for a dairy cow, with the exception that no allowance is required for milk production. For example, the ration outlined for a horse on page 198. To determine the standard for a 1600-pound horse, multiply the allowance for a 1000-pound horse, as outlined in the Morrison Standards, by 1.6. Calculate the amounts of dry matter, digestible protein, and total nutrients in the first trial ration, and compare these and the nutritive ratio with the standard as follows:

Ration	Dry Matter	Digestible Protein	Total Digestible Nutrients	Nutritive Ratio
Prairie hay, 19 lb.	17.765 lb.	.760 lb.	9.101 lb.	
Oats, 18 lb.	16.344 lb.	1.746 lb.	12.672 lb.	
Total	34.109 lb.	2.506 lb.	21.773 lb.	1:7.68
Standard for 1600-lb. horse at hard work.	28.8–35.2 lb.	2.40–2.88 lb.	20.8–24.0 lb.	1:7.6–8.1

It is seen that the ration is within the limits of the standard in dry matter, digestible protein, total digestible nutrients, and the nutritive ratio. If it had been above or below in any part, one of the feeds would have had to be increased or decreased. A shortage in some part of a ration may be corrected by adding a feed not already included.

Rules for Use in Arranging Rations.—In order to assist the student in the calculation of practical balanced rations

the following rules have been selected, from *Feeds and Feeding* by Henry and Morrison.

Horses at work should be fed 2 to 2.5 pounds of feed (dry roughages and concentrates combined) daily per 100 pounds live weight, the allowance of concentrates ranging from 0.7 to 1.4 pounds per 100 pounds live weight for horses at medium to hard work.

Dairy cows in milk will eat 2 pounds of good quality dry roughage or 1 pound of dry roughage and 3 pounds of silage daily per 100 pounds live weight. Sufficient concentrates should be fed in addition to bring the nutrients up to the standard, generally about 1 pound of concentrates to every 3 to 5 pounds of milk produced.

Fattening cattle should receive 2.1 pounds or more of concentrates and dry roughage (or the equivalent in silage) daily per 100 pounds live weight, the allowance of concentrates ranging from less than 1 pound to 1.7 pounds or more per 100 pounds live weight.

Fattening lambs will consume about 1.4 pounds of dry roughage daily when fed all the grain that they will eat, and up to 2.3 pounds or over when the grain allowance is restricted. 3 pounds of silage may replace 1 pound of dry roughage.

Pigs can make but limited use of dry roughage.

It is suggested that all students become thoroughly familiar with the foregoing rules, at least, for feeding horses and dairy cattle, and with the other rules when they require them in actual practice. Many of the most successful farmers always work out on paper the rations for their live stock. The cost of the ration must constantly be kept in mind. Protein is the most expensive food nutrient.

Amounts of oil cake to feed.—It must be remembered that oil cake is expensive. The following amounts are suggested: for dairy cattle, 1 to 2 pounds daily; for horses, 1 to $1\frac{1}{2}$ pounds; for fattening cattle, 2 to 3 pounds; for lambs, $\frac{1}{8}$ pound; and for pigs a small amount per day.*

Exercises.—(1) Calculate the nutritive ratio of the following ration for an 1800-pound horse at hard work; timothy hay, 19.8 pounds, and oats, 22.5 pounds. Is the nutritive ratio within the limits set by the Morrison Feeding Standards? Is the ration balanced?

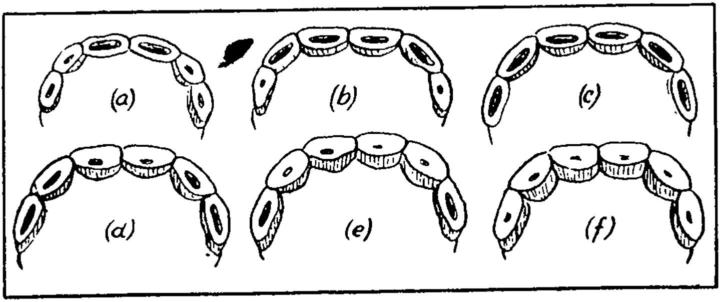
*From *The Book of Live Stock*, by Wade Toole.

(2) Adjust the foregoing ration to make it suitable for a horse of the same weight at medium work.

(3) A cow not milking is being wintered on a ration of oat straw, 20 pounds, and oat chop, 8 pounds. Find the nutritive ratio of this ration.

(4) What difference would the addition of ½ pound of oil cake make in the nutritive ratio of the ration in Exercise No. 3.

(5) Compound a ration for an 1100-pound cow producing 20 pounds of 4 per cent milk daily, using prairie hay, oat chop, oil cake, and bran. (Use 1.5 pounds of oil cake and 3 pounds of bran.)



Dentition in horses. (a) The teeth of a three-year-old, two permanent incisors. (b) Four-year-old, four permanent incisors. (c) Five-year-old, six permanent incisors. The incisors appear in pairs as outlined in both upper and lower jaw at the same time. (d) Six-year-old, the cups have disappeared from the central pair of incisors in the lower jaw. (e) Seven-year-old. (f) Eight-year-old, the cups have gone from all incisors in the lower jaw. (g) At nine years the cups disappear from the central pair of upper incisors, at ten years from the next pair, and at eleven years from the outside side pair.

(6) Have the feeds suggested for the ration in Exercise No. 5 been wisely selected? Name some other feeds that you think are more suitable. Give reasons for your selection.

(7) Consult the *List of Publications* of the Department of Agriculture, Ottawa (given on page viii). In the live stock section you will find a number of bulletins which discuss the feeding of the various classes of farm animals. Send for these publications and, after studying them, compound other balanced rations.

The Teeth of Farm Animals.—When buying sheep, it is important to examine the mouth of each one to see that the teeth are in good condition, and it is a good plan to have horses' teeth examined occasionally for the same reason.

The age of some animals may be determined by an examination of their teeth. (See drawings on pages 207 and 214.) The number of teeth which the various farm animals have is shown in the following table, which should be used only as a reference.

Animal	Jaw	Incisors or Cutting Teeth	Canines	Molars or Grinding Teeth	Total
Horse	Upper	6	2	12	
	Lower	6	2	12	40
Cow	Upper	a tough pad only	0	12	
	Lower	8	0	12	32
Sheep	Upper	a tough pad only	0	12	
	Lower	8	0	12	32
Pig	Upper	6	2	14	
	Lower	6	2	14	44
Dog	Upper	6	2	12	
	Lower	6	2	12	40

The Essential Features of a Stable.—From the standpoint of labor, the stable must be planned for convenience. For the animals, cleanliness, light, ventilation, dryness, and warmth are necessary. The stable should not be too warm. A good supply of fresh air must not be sacrificed for a high temperature. On the other hand, a cold stable is not always well ventilated. Proper ventilation requires an arrangement for the free exchange of impure air from inside the stable for fresh air from without. Barns do not have to be expensive. Costly shelters do not always return interest on the money invested. (For problems and suggestions in

the cost of sheltering farm animals, see page 262.) It is a good plan to whitewash the stable at intervals, using a 5 per cent solution of carbolic acid in the whitewash.

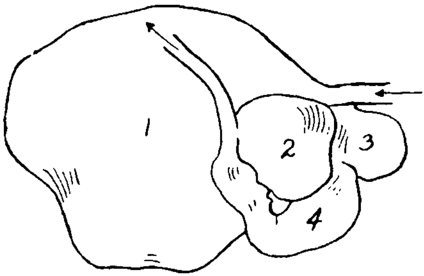
The Care and Feeding of Horses.—*The Colt.*—The essentials of successful colt-raising are cleanliness, exercise, fresh air, and proper feeding. The colt should be taught early to eat grain, and weaned at from four and a half to six months of age. The object in feeding is to keep the colt growing steadily, but not fat. It is advisable to feed often, and to use good muscle and bone building feeds. A little salt, plenty of clean bright hay,and pure water are necessary. The colt's education should be commenced while it is quite young. The feet of young horses should be trimmed at intervals as required.

The Farm Work Horse.—A horse is fed to produce energy. The daily allowance of feed depends upon the severity of the work. Oats and bran are the best concentrates, and the roughage should consist of bright clean hay, such as timothy or other good grass, or grass and clover or alfalfa. The digestive system of a horse is very sensitive and easily put out of order. For this reason great care should be taken not to feed any moldy or dusty hay. Caution must also be observed when watering. After hard work or fast driving, the horse should not be allowed to drink a large quantity of water until he is cool. It is important to reduce the concentrates of the ration when the horse is idle for a few days. Failure to do this often results in paralysis and death. During the winter horses should be fed for maintenance only. Roughage can be used for most of the ration, although a few pounds of grain may be necessary to keep them in good condition. The horse should be fed regularly. A variety of feeds will give good results, although sudden changes in the kind or amount of feed must be avoided, as these are very liable to cause serious digestive

troubles. There should be some rock salt in the mangers at all times. Great care must be taken to have the harness, especially collars, fitted properly to prevent sore shoulders, etc. Bathing the shoulders with cold salt water to toughen them is a good practice, especially on commencing work in the spring, when the shoulders are soft and tender after an idle winter. The horse's feet should be trimmed carefully and often to prevent them from growing out of shape. At night, after a hard day's work, the horse should be thoroughly groomed as soon as dry in order to keep his hide in a good healthy condition.

The Feeding and Care of Dairy Cattle.—The *calf* is usually removed from its mother three or four days after birth. It is more profitable to separate the milk, sell the cream, and feed the skim milk to the calf, which should be taught to drink from a pail at once. The change from whole milk to skim milk should be gradual, and, as the amount of whole milk is reduced, it is a good plan to substitute something for the cream. For this purpose flax-seed jelly is recommended. Calves should be fed three or four times a day at first, gradually changing to twice daily when they are about three weeks old. Milk must always be fed as soon as possible after being drawn from the cow and at a temperature of 90° to 100° F. When about three weeks old, the calf should be taught to eat a small quantity of oats, bran, oil cake, or pulped roots. Nothing is better than legume hay, as it is rich in protein and mineral matter. The amount of grain should be increased gradually, feeding each time just what the calf will quickly clean up. At about five or six months, the calf should be put on a grain ration entirely. Plenty of fresh water and some salt must be provided. A clean, dry, sunshiny, warm place is necessary. Overfeeding, cold sour milk, and unclean pails cause most of the trouble experienced in feeding calves.

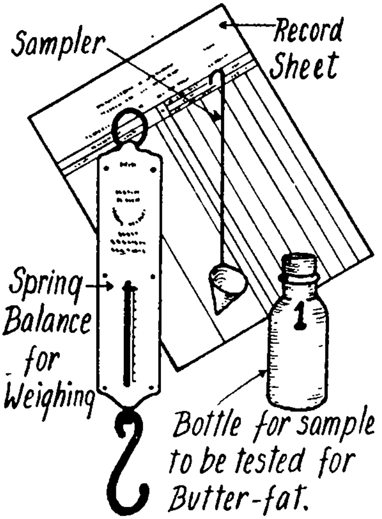
The object in feeding the *dairy cow* is to produce milk, not to fatten. The feed should be palatable, succulent, easily digested, and abundant. Cattle (and sheep and goats) are ruminants; that is, they chew the cud. These animals have four stomachs. When the food is first swallowed, it passes into the first stomach or paunch. It is then returned to the mouth, chewed again, and re-swallowed, passing into the second, third, and fourth stomachs successively. The nature of the ruminant's digestive system requires a large amount of bulky food. Regularity in feeding is essential as to both time and character of the feed. Clover or alfalfa is an excellent dry roughage. Pasture should be provided in summer; and roots, silage, or green feed are required when pasture is not available. There must be a variety of feed. The individual appetite of each cow must be considered; what will do for one may be of little value for another. Water and salt should be available at all times. The cows should be cleaned and groomed regularly, and should be milked at regular hours, at least twice daily.



The digestive system of a cow, showing the necessity of feeding cattle a large amount of roughage. The stomach and intestines of a cow have almost twice the capacity of those of a horse.

The Management of a Dairy Herd.—Cow Testing.—It has already been pointed out that proper feeding is essential if the dairy cow is to produce a maximum yield of milk. Regularity in milking has also been previously discussed. The cows themselves must be large and of high milk-producing ability. Milking qualities are inherited (see page 219) and cannot be developed in cows whose ancestors were

poor milk-producers. A sire from a family of heavy producers is essential. A good sire has more influence than any other member of the herd on the quality of the offspring (see page 219). Even if a dairyman starts with only fair cows, he may in a few years develop a herd of heavy milkers by the use of the best sire which he can afford. It is also necessary that the record of performance of each cow should be determined. A knowledge of the total production of a herd means very little. A few of the cows may be yielding most of the milk. Testing the individual cow is therefore important. The good cows should be selected to build up the herd, and the unprofitable ones discarded.



Cow-testing apparatus. See page 224 for the Babcock test apparatus. (Draw.)

Cow testing is conducted as follows: (1) Weigh the milk of each cow three times a month, the 10th, 20th, and 30th, both morning and night. (2) Take samples each time and test for butter-fat, or place the samples in a bottle, with a preservative to prevent them from spoiling, and test the composite sample at the end of each month. (3) Careful records must be kept of all weighings and tests. (4) The test should be conducted for the entire lactation period. A cow may produce a large amount of milk for a short time, but the most profitable cow is the one that milks heavily for ten or eleven months, producing from 12 to 15 quarts per

day at least. Yields of 10,000 to 15,000 pounds of milk a year per cow are no longer uncommon.

The Feeding and Care of Beef Cattle.—The *beef calf* is fed on skim milk for the first summer. Practically the same methods as outlined for the dairy calf are recommended. During the following winter it should be given roughage and a small allowance of grain. The second summer, the calf is pastured, then fattened during the winter.

Baby beef is the term applied to cattle that are finished and marketed under eighteen months of age. They must be left with the dam for nine or ten months and fattened as they grow. Towards the end of the feeding period they should receive a good grain ration.

The object in *fattening cattle* is not the accumulation of fat, but the improvement in quality of the meat by depositing fat through the lean meat tissue. Most cattle are fattened before they are fully matured (two to three years old), in order to take advantage of increased weight through growth. One of the most profitable methods of fattening cattle is to buy them on the market in the fall, when cattle are coming in from pasture and prices are low, fatten them during the winter (usually about six months), and sell in June when prices are high. To make a profit in this way it is necessary to have an increase in price as well as in weight. Cattle should be dehorned before feeding is commenced. It is usual to commence with a light ration and increase the allowance to the full amount in about six weeks. Salt must be supplied. The best grains are corn and barley, supplemented by linseed meal. Legumes, silage, and roots are necessary. The cattle may be winter-fed either in the barn or out-doors.

Marketing beef cattle.—It is important to have the cattle finished in the right condition and when prices are highest. If they are ready too soon, the extra feed consumed reduces

the profits, or, if not finished on time, they must be sold too thin or after prices have gone down. *Many of the beef cattle produced in Canada are exported to Great Britain or the United States.* There is usually a good demand in these countries for live Canadian cattle, both finished and feeders. *Feeders* and *stockers* are cattle purchased to be taken back to the farms for further feeding and fattening.

The Feeding and Care of Sheep.—Sheep, more than all other farm animals, should be kept dry. Shelter can be very inexpensive, as sheep withstand a great deal of cold when not allowed to get wet. The danger is that they may be kept too warm during the winter, but they should not be exposed to draughts. Plenty of exercise is essential. Barley and oats are the best grains and should be fed whole. Hay should be fed in racks and not on the ground. Turnips and alfalfa make excellent winter feeds. Sheep are best wintered on succulent roughages—overfeeding must be avoided. Salt should always be available. Sheep are the weed scavengers of the farm, and may be profitably pastured on weedy summerfallows.

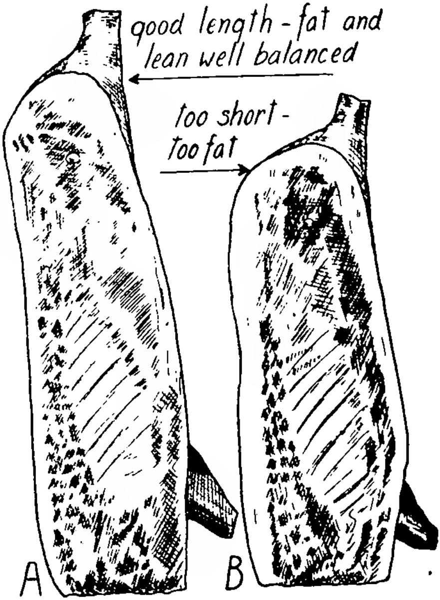
The teeth of sheep. (a) Twelve to fifteen months old, two central permanent incisors. (b) Two years old, four permanent incisors. (c) Three years old, six permanent incisors. (d) Four years old, eight permanent incisors. (See page 207.)

At lambing time constant attention is required of the shepherd to avoid loss. The ewe will often neglect the lamb if the shepherd is not there. Lambs should be taught early to eat grain, by the use of a "lamb-creep". They are weaned at from four to five months of age, and should have an abundance of good pasture during the summer. All lambs should be docked when two or three weeks old.

The flock must be clipped as soon as the weather is warm, usually during the last three weeks of June. Clipping

should be followed in a week or two by dipping, which consists in immersing the sheep in a creoline solution or specially prepared sheep dip, to destroy the ticks that infest them. When the time arrives to fatten the sheep, regularity in feeding and quiet are necessary. Lambs should be put on a full ration gradually.

The Care and Feeding of Swine.—Next to the dairy cow, hogs produce more human food per pound of feed consumed than any other farm animal. Hogs should be ready for market at about six months of age, when they should average about 200 pounds in weight or, to be more exact, from 170 to 220 pounds when they arrive at the stockyards. To secure the best bacon it is necessary to start with the right type of hog. (See page 185 for market standards.)



Wiltshire sides. A, the desirable type for export trade, from a select bacon hog. B, an undesirable type.

Pigs are weaned at about eight weeks of age. They should be taught, two or three weeks after birth, to eat a thin mixture of grain and skim milk. This should be placed in a shallow trough in a "creep" to prevent the old pig from reaching it. A good grain is ground oats from which the hulls have been sifted. Pigs are growing right

up to the time when they are marketed, and for most profitable results they must be fed muscle and bone building feeds. Bran or shorts, green feed, and a little charcoal are required in the ration. Large amounts of barley should not be used, as it tends to fatten the pigs too much. Plenty of exercise at all times is essential, and an alfalfa pasture is ideal for this purpose. When the pigs are about four months old, the skim milk may be reduced and the amount of grain increased. Fresh water must always be available. Hogs should be fed regularly, usually twice a day. Overfeeding must be avoided.

Exercises.—(1) The feeding and care of the different classes of farm animals may be summarized under several headings: (*a*) general principles, such as ventilation, cleanliness, etc., which apply to all classes, (*b*) the rules for the amount of feed, page 206, (*c*) feeds suitable for the particular animals being discussed, (*d*) special considerations, such as the harness and feet of horses, the milking of dairy cows, the shearing and dipping of sheep, etc. Make out such a summary for horses, dairy and beef cattle, sheep, and swine.

(2) Inquire of live-stock men in your district where they market their stock.

(3) Clip several live-stock market reports from the daily papers. Learn the names of the grades of cattle and hogs listed. Which grades sell for the highest prices? If you do not understand what the names of the grades mean, ask a live-stock man.

(4) The principal Canadian markets for live stock from Western Canada are *Edmonton, Calgary, Prince Albert, Moose Jaw, Winnipeg, Toronto,* and *Montreal.* Many of our cattle are also marketed in *British Columbia.* Draw an outline map of Canada and mark these points. Draw an arrow pointing towards Great Britain and mark on it *Export of bacon and live cattle to Great Britain.* Point an arrow towards the United States and mark on it *Export of cattle to the United States.*

(5) Watch the newspapers for announcements about the export of live stock to Great Britain and the United States. When such notices appear, clip them out and paste them into your note-book.

Projects.—(1) Every school should have a Babcock milk-testing outfit. Invite the farmers in the district to send samples of milk from

their cows to the school at intervals to be tested. Organize a cow-testing club. The Dairy Branch in Saskatchewan will pay boys and girls well for milk-testing work in that province. Write to them for particulars.

(2) Draw a graph or chart to show the fluctuation of the price of "select" hogs or other grade of live stock. (See directions for drawing wheat price graph on page 277.)

(3) Make a study of the live stock industry of Canada, particularly of the West. In which province are the largest number of horses, cattle, sheep, swine, and poultry raised? What are the difficulties which confront the farmers who are raising live stock.

(4) Students should be encouraged to engage in a practical live-stock project, such as the feeding of well-bred colts, calves, sheep, or pigs. Stock-judging competitions, should be organized. When suitable arrangements can be made, feeding experiments should be conducted. Animals, owned and fed by the students, should be exhibited at various fairs. If the teacher cannot undertake this work, there is usually someone else in the community who can be persuaded to assume the responsibility.

CHAPTER XIII

THE IMPROVEMENT OF FARM ANIMALS THE VALUE OF LIVE STOCK—ANIMAL PRODUCTS OF THE FARM

The Improvement of Farm Animals.—The production of better live stock is based upon the same principles of *variation, heredity,* and *selection* that underlie plant improvement. (See page 113.) *Crossing* is also practised to some extent but is made use of chiefly to produce animals for special purposes.

Exercise.— Define or explain, with special reference to animal life, and give examples in each case of: variation, variation due to environment, variation due to crossing, mutation, selection, natural selection, and artificial selection.

Heredity.—**Exercise.**—Observe among some live stock several parent animals and their offspring with reference to peculiarities of conformation, color markings, size, disposition, etc.

When the foregoing exercise has been undertaken, it will be found that the offspring, in the majority of cases, more or less closely resemble their parents. If the parents are deep, wide, lowset in conformation, these qualities will be transmitted to the offspring. The transmission or passing down of characters from parent to offspring is known as *heredity.* All the characters of an animal must have been present in some one or other of its ancestors. The proportion in which the inheritance of characters occurs is considered to be as follows: 50 per cent from the parents, 25 per cent from the grandparents, 12½ per cent from the great grandparents, and so on. In breeding live

stock we do not produce animals with new characters but animals possessing characters previously present in some ancestor, and, unless the ancestors have been good individuals, it is impossible to produce good qualities in the offspring. *It is also important to remember that undesirable characters, such as poor conformation, weak constitution, etc., are just as surely and as frequently inherited as good qualities.*

Selection.—Since both good and bad qualities of parent animals are inherited by their offspring, it is plain that the successful breeder must practise the most rigid selection in the choice of the animals that he mates together. Poor animals, carelessly selected, will produce poor animals; while animals of good type, conformation, and ability will produce offspring possessing these good qualities.

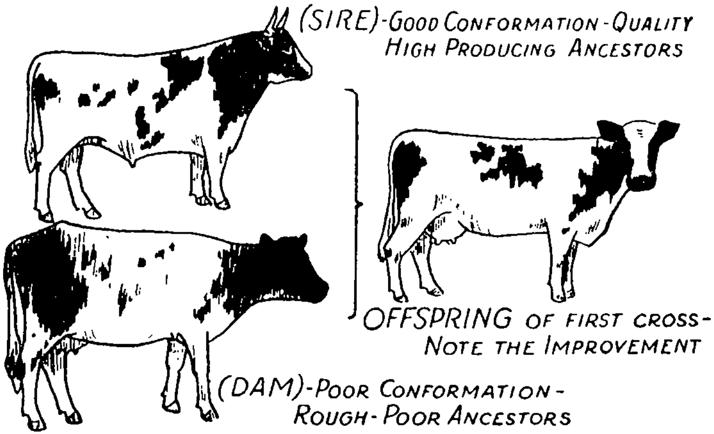
For example.—(1) A dairyman wishing to breed good dairy cattle must keep only cows of lean, wedge-shaped conformation and high milking ability, from which to raise calves, because good milking qualities are inherited and cannot be developed, to any extent, in a cow unless present in her ancestors.

(2) A "select" bacon hog weighing 200 pounds will sell for 8 cents a pound, or $16.00, while a larger hog of the thick type weighing 240 pounds can be disposed of for only 6 cents a pound, or $14.40, that is $1.60 less. Both hogs require the same amount of feed and care, but one is correct in type and meets the requirements of the market, and is therefore worth more than the other. The characters of the "select" bacon hog are inherited, and breeders who carefully and intelligently select the right type of parent can produce bacon hogs much superior to those produced by breeders who do not make such a selection.

The Importance of a Good Sire.—Since, in herds or flocks of farm animals, there are usually several females and one male or sire, it is evident that, while each female

transmits her characteristics to only one of the offspring, all of the offspring inherit characteristics from the male. The male, therefore, has the greatest influence upon the improvement or retrogression of the herd or flock, and it is essential that this individual be the best that the breeder can possibly afford.

Registered Pedigreed Stock.—Pure-breds.—It sometimes happens that when two good animals are mated



The value of a good sire in improving a dairy herd.

together, inferior qualities not visible in either parent appear in the offspring. Where do these undesirable characters spring from? They have been inherited from the grandparents or great grandparents as outlined above in the paragraph on "Heredity". Therefore, to guard as much as possible against this occurrence it is necessary for the breeder to know the ancestry of his breeding stock. For this purpose records, known as *pedigrees*, have long been maintained by breeders of good live stock. To be official, pedigrees, with the exception of those of Holstein-Friesian

cattle, must be registered with the Canadian National Livestock Records Association, Ottawa.

The Extended Pedigree of a Shorthorn Bull

Star of Hope =122595= Date of birth, Nov. 2nd, 1917. Bred by J. G. Barron, Carberry, Man.	Emma's Prince =95009=	Missie's Prince	=83660=
		Emma of Oak Bluff	=99707=
	Rosa Hope's Pride =102936=	Scotch Thistle	=72489=
		Rosa Hope 18th	=84447=

A *pure-bred* is an animal with an official pedigree, which proves that all its ancestors have been members of the same breed for many generations.

Crossing.—Crossing means the mating of two individuals of different breeds. For example, on the range, Shorthorns and Herefords are sometimes crossed to produce steers with the smoothness and size of the former and the constitution and rustling ability of the latter. These *cross-bred* animals have been produced in this way to give them qualities for which they can be sold more profitably. They would not be useful for breeding purposes, as they possess the blood lines of two different breeds. It would not be possible to foresee what characteristics the offspring would be likely to inherit. Better results are usually obtained by mating together pure-bred animals, as Shorthorn with Shorthorn, Yorkshire with Yorkshire, etc.

Scrubs.—Grades.—A *scrub* is an animal without a recorded pedigree, that is, its breeding has not been methodically improved. Such animals are usually very poor, undesirable individuals. A *grade* is an animal with one pure-bred parent, which is most frequently the sire. When a herd of scrub cows is headed by a pure-bred sire, the offspring are grades.

Exercises.—(1) Distinguish between the terms *pure-bred* and *Thoroughbred* as applied to live stock. Give examples.

(2) Secure a pedigree from a breeder and make a copy of it.

(3) What suggestions, other than those of feed and care, would you make to a farmer who wishes to improve the milk yield of his herd of grade cows or the quality of his beef cattle, draft horses, etc.? Give reasons for your recommendations.

Project.—Make a survey of the live stock of the district. Prepare a list of the pure-bred cows and their milk records and compare with the scrub cows. Are there any scrub sires? How many pure-bred sires do you find at the head of grade herds? How many pure-bred sires heading pure-bred herds? Decide whether the quality of the live stock in the district is improving or not.

The Value of Live Stock in Farming.—It is the opinion of all who understand the business of farming that live stock are necessary to good agriculture. Briefly, the advantages of raising live stock are as follows: When part of the farm is used to raise live stock, the manure may be applied to the soil to restore the fibre destroyed by grain-growing—thus the danger of soil-drifting is reduced, and the fertility of the soil is maintained. Live stock are another source of revenue, and reduce the risk of farming—the farmer who raises live stock has an income even if his crops fail. Animals on the farm are valuable to make use of otherwise waste products—skim milk may be fed to calves and pigs, sheep may be kept on weedy summer-fallows, damaged or low-grade grain that has little value as grain may often be used to feed cattle or pigs. The coarser grains, such as barley and oats, grasses and legumes, can frequently be disposed of more profitably when fed to live stock than when sold as grain or hay. Live stock supply food, and in this way they help to reduce the living expenses of the farmer and his family. When live stock are kept, there is work to be done all the year around—a more even distribution of work throughout the year helps to solve the labor problems of the farmer. A good crop rota-

tion is possible when there are animals to make use of grass and legume crops. Live stock tend to put farming on a safer, more permanent basis, and therefore they must become one of the main branches of agriculture in Western Canada and not merely a side-line.

The Dairy Industry in Western Canada.—Dairying is every year becoming more and more important as a source of wealth, and as a factor in reducing the risks of farming and maintaining the fertility of the soil. Explain fully each point made in the foregoing statement. Dairy products from the prairies are now being marketed in British Columbia, Eastern Canada, Great Britain, and other parts of the world. Canadian butter and cheese must be sold in the British and other markets in keen competition with the dairy products of New Zealand, Australia, the Argentine, Denmark, Siberia, and a number of the Central European states. If Canada is to secure her share of the dairy business of the world, Canadian dairymen must exercise every precaution to see that their products measure up to the highest standards of quality.

The Constituents of Milk.—**Exercises.**—(1) Place about 25 c.c. of milk in a beaker and boil. Collect the scum that gathers on the top of the milk and remove it to a test-tube by means of a stirring rod. Test the scum for protein as in Exercise No. 4, page 190. This *protein*, which is coagulated or thickened by heat, is called *albumen*.

(2) To the portion of milk that remains in Exercise No. 1, add a few drops of acetic acid or vinegar. Stir well. When a thick curd is formed, filter. Save the filtrate (the liquid that passes through the filter paper) for Exercise No. 3. Test the curd for protein. This *protein*, which is thickened by an acid, is known as *casein*.

(3) Pour a couple of c.c. of the filtrate obtained in Exercise No. 2 into a test-tube and add an equal quantity of Fehling's solution (see page 191). Heat gently. A reddish brown color indicates the presence of *lactose* or *milk sugar*.

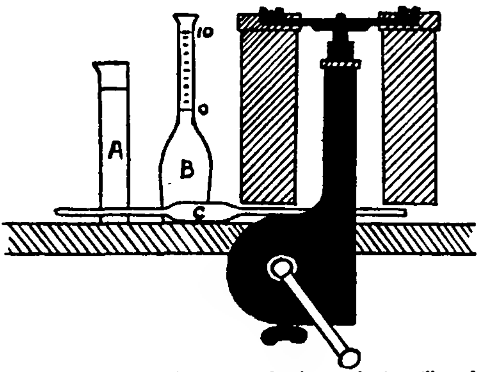
(4) Examine a drop of milk or cream under a low-power microscope. Observe the tiny globules of *butter-fat*.

The butter-fat in milk is a mixture of several fats. It is the lightest constituent, and is held in suspension in the form of tiny globules $\frac{1}{15,000}$ to $\frac{1}{25,000}$ inch in diameter. Besides the constituents indicated in the foregoing experiments, there is *ash* or *mineral matter* and *water*. Milk is also rich in *vitamines*, which have been found so essential to growth and health. Milk is considered to be a perfect food, especially for young animals. Explain the functions which each of the constituents of milk will have in the life process of the animal body. (See page 192.)

Chemical Composition of Milk

Water	87.5 per cent
Fat	3.8 per cent
Casein	2.6 per cent
Albumen	.7 per cent
Sugar	4.7 per cent
Ash	.7 per cent
Total	100.0 per cent

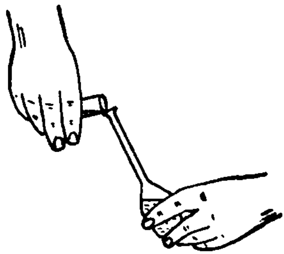
The Babcock Test.—This test is used to determine the percentage of butter-fat contained in milk, cream, skim milk, buttermilk, condensed milk, and whey. While the procedure varies slightly in each case, all tests are the same in principle. The procedure with milk is as follows:



Apparatus for the Babcock test for butter-fat in milk and cream. A, the acid measure; B, the test-bottle; C, the pipette. (Draw.)

(*a*) Thoroughly mix the sample of milk. This is best done with a small amount by pouring it back and forth from one vessel to another.

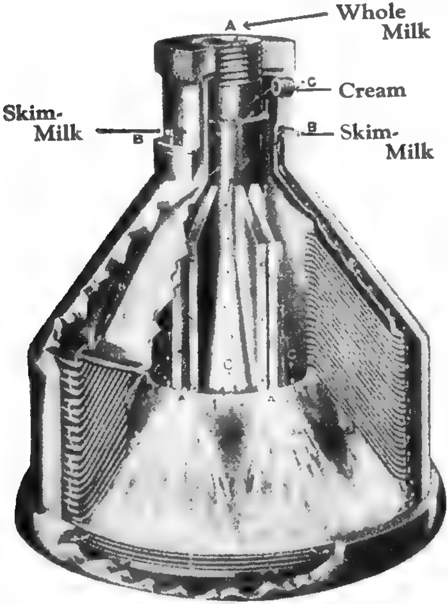
(b) By means of a 17.6 c.c. pipette, measure 17.5 c.c. of milk into a test-bottle (.1 c.c. of milk adheres to the sides of the pipette). Suck the milk some distance above the 17.6 c.c. mark on the stem of the pipette, quickly place the finger over the upper end, release the pressure of the finger slightly and allow the milk to run down to the mark. Holding the bottle on a slant, insert the end of the pipette and carefully allow the milk to flow down one side of the neck. (c) Fill the acid cylinder to the 17.5 c.c. mark with sulphuric acid (specific gravity 1.82-1.83). If only stronger acid is available, use less. Holding the test-bottle on a slant, carefully pour the acid into the bottle. Turn the bottle slowly around so that the acid washes down any milk in the neck. There should now be two layers in the bottle—the milk above the acid without much of a dark band between. (d) To mix the acid and milk hold the bottle by the stem and gently rotate it until a dark, uniform color results. Be careful not to splash the contents of the bottle into the neck. Note the heat produced. (e) Place the bottle in the tester. Be sure that the machine is balanced. It is a good plan to make at least two tests so that the bottles can be placed opposite to each other in the centrifuge. Whirl for five minutes at the speed indicated on the tester. (f) Stop the machine and add hot water to bring the contents of the bottles to the base of the neck. (g) Whirl for three minutes. (h) Stop and add more hot water to float the fat into the neck of the bottle—drop the water this time directly on the fat. (i) Whirl for one minute. (j) Measure the percentage of fat in the milk by means of dividers. Place the lower point of the dividers at the extreme bottom of the butter-fat column, and the top point at the extreme top. Drop the dividers until the lower point touches the zero mark, and the upper point will indicate the percentage of fat in the sample. (k) The bottles should be emptied immediately, washed with hot water and washing soda, then rinsed with clean water.



How to hold the test-bottle when adding acid or milk.

NOTE.—Every school should have a copy of Bulletin No. 14 N.S., *The Testing of Milk, Cream, and Dairy By-products by means of the Babcock Test,* distributed by the Department of Agriculture, Ottawa. Study this bulletin carefully to avoid mistakes when conducting a Babcock test, and also to learn how to keep the test-bottles clean.

The Principles of the Babcock Test.—(1) The fat is the lightest constituent of the milk. (2) The acid dissolves all the constituents of the milk, except the fat, and increases their specific gravity. (3) The centrifugal force developed by the rapid whirling throws the heavier constituents to the outside of the whirl, and leaves the fat in the centre or at the top of the bottle.



Courtesy of The Massey-Harris Co., Ltd.

A section through the bowl of a centrifugal cream separator. By following the arrows trace the path of the whole milk into the bowl and the skim milk and cream out of the bowl. Explain how the cream is separated from the skim milk.

Cream.—Cream is produced by collecting the butter-fat into a small portion of the milk serum. It may be separated from the other constituents by allowing the milk to stand in pans, either quite shallow or deep, or by means of the centrifugal cream separator. In either case, the separating should be done as soon as the milk is drawn from the cow. Why?

Bacteria in Milk.—There are many forms of bacteria (see page 132) found in milk. It has been estimated that under certain conditions there may be present from 500,000 to 8,000,000 per cubic centimetre—of course this would not be the case in fresh, clean milk. The majority of these micro-organisms are friendly and useful, for example, the lactic acid bacteria, which are responsible for the souring

of milk, and also assist in digestion. The harmful forms are those that cause milk to decay. Under certain conditions organisms that produce ropy or stringy milk and pathogenic or disease-producing bacteria may also be present. State the different sources from which bacteria may enter the milk.

The Souring or Ripening of Milk.—This condition is brought about naturally by the *lactic acid bacteria.* The bacteria produce a ferment, which breaks down the milk sugar, forming lactic acid. The acid thickens and precipitates the casein. The precipitate is known as *curd,* and the liquid left is called *whey.*

Exercises.—(1) Test a sample of sour milk with blue litmus paper. A red color indicates the presence of an acid.

(2) Review Exercise No. 2, page 223.

Safeguarding Milk by Pasteurization.—The bacteria or germs causing typhoid fever, diphtheria, tuberculosis, and other diseases find a very favorable growing-place in milk, and may be widely spread by this means. They may be destroyed and the milk made safe by pasteurization. The process most commonly used consists of heating the milk in large vats to a temperature of 145° F., holding it at this temperature for thirty minutes, then quickly cooling it to 45° F., and keeping it at this temperature until delivered to the consumer. Properly pasteurized milk will keep better than other milk, although it should and will sour. When too high a temperature is used, the lactic acid bacteria are destroyed, and the milk will remain sweet even after it has begun to decay. Distinguish between pasteurizing and boiling. Are there any objections to pasteurized milk?

Certified Milk.—Certified milk is high-quality milk produced under particularly sanitary conditions under government supervision. It is not pasteurized but must have a very low bacterial content.

The Production and Marketing of Milk and Cream.—Milk and cream can be delivered to the consumer in a sweet and wholesome state only when produced under conditions of absolute cleanliness and promptly cooled and held at a low temperature (50° F. by law). The cows must be free from disease, especially tuberculosis, and kept in clean, sunshiny

A motor-driven cream separator in a modern dairy. Notice the general appearance of cleanliness, the screen door, the pail up-turned on the shelf, and the tilted lid of the cream can. Look for the cream spout and the skim-milk spout of the separator.

surroundings. Clean feeds and fresh, pure water are essential. The flanks and udders of the cows should be well brushed off just before milking is begun, and no feed or litter should be moved about the stable immediately before or while the milking is in progress. The attendants must be free from disease, and their hands and clothes must be clean when milking. In no circumstances should the milking be done with wet hands. Small-topped, seamless pails are best. All utensils must be thoroughly sterilized by scalding each time that they are used. Daily exposure to sunlight helps

to keep them sweet and clean. As soon as the milk is drawn, it should be removed from the stable, strained, separated, and cooled.

When a farmer sends milk or cream to the creamery, it is weighed and tested, and payment is made according to the pounds of butter-fat which it contains. Farmers who live at a distance from the creamery usually find that it pays better to ship cream. Why? Milk and cream should be shipped in tightly covered cans by the quickest method, and should be allowed to stand in the sun only when absolutely unavoidable. Heat encourages the activity of the lactic acid bacteria, and sour cream grades lower than sweet. Cream is graded as follows:

Table Cream—sweet, clean flavored, suitable for household use.

Special Cream—clean flavored, for Special Grade Butter, under .30 per cent acid.

First Grade—reasonably clean flavored, for First Grade Butter, under .60 per cent acid.

Second Grade—off in flavor, for Second Grade Butter.

Off Grade—objectionable odor or flavor, unfit for Second Grade Butter.

Butter-making.—The production of good butter begins with the cow. Cleanliness is essential throughout. Cream that tests from 30 to 35 per cent butter-fat is recommended. It should be kept cool and sweet until enough has been gathered for a churning. When fresh cream is being added to the supply on hand, it must first be cooled, then well stirred into the main lot. To ripen the cream it is heated to 70° F., until it starts to thicken. It is then cooled to churning temperature and held for several hours. When ready to churn, the cream should have a pleasant taste and smell, and be smooth and free from lumps. Large quantities of butter are now being made from sweet cream, which produces a milder flavored product.

The temperature of the cream when put into the churn should be such as to bring the butter in the size of plump wheat kernels in from twenty-five to thirty minutes. Churning temperature varies a great deal according to the richness of the cream and the season of the year. Too high a temperature produces weak-textured butter, and low temperatures bring the butter very slowly. A barrel churn is best. It must be well scalded, then cooled by cold water before being used. Enough cream should be poured through a strainer into the churn to fill it about one-third. If necessary, coloring material, 1 to 4 drops per pound of butter, is now added. In order to secure proper percussion the churn should not be turned too rapidly. It is usually necessary to open the gas valve several times to allow the gas that forms to escape. The clearing of the glass in the top of the churn indicates that the churning has "broken". When the butter is about the size of plump wheat or corn, the buttermilk is drawn off, and the butter is washed at least twice with water a few degrees lower than the churning temperature. Care must be taken to wash out thoroughly all the buttermilk. Salting is more satisfactorily done in the churn. One-half of the salt is sprinkled over the butter and mixed by tilting the churn back and forth. The balance of the salt is then added, and the churn is revolved several times. Salt, at the rate of from ½ to 1 ounce per pound of butter, improves the flavor and keeping quality, and expels excess moisture.

After the salt is thoroughly mixed into it, the butter is removed from the churn to the worker. Working should be done only to squeeze out the water and further mix the salt. Slicing or rubbing with the worker must be avoided—a pressing motion only is required. Overworking produces a broken grained, greasy butter. When the working is complete, the butter is packed into clean crocks or in pound

prints. In each case it should be wrapped in parchment paper. A cardboard carton for each print is desirable. Every package of butter should have on it the maker's name and the kind of butter.

Exercises.—(1) See page 268 for suggestions in the marketing of butter. Is there a Butter Pool or a Co-operative Creamery in your district? What are the advantages of these organizations? Compare creamery and dairy butter.

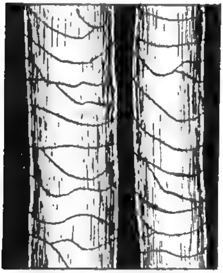
(2) What quantity of butter can be made from 500 pounds of cream testing 35 per cent butter-fat? One pound of butter-fat will produce $1\frac{1}{4}$ pounds of butter. What materials become mixed with the fat to make the additional $\frac{1}{4}$ pound?

The Production of Cheese.—Cheese is manufactured from the casein of the milk. Rennet, an extract from calves' stomachs, is used to ripen the milk and separate the casein (curd) from the other constituents. When the curd is firm, the whey is strained off, and the curd may be salted and used fresh as *cottage cheese.* To make hard or *Cheddar cheese* a firmer curd is produced. It is cut up into small cubes, and the whey removed, after which it is salted and packed into moulds or presses, where it is held until all of the free whey has been squeezed out. Finally, it is held at a low temperature for several weeks to ripen or cure. During the ripening process certain forms of bacteria become active and impart the flavor to the cheese. By inoculating newly-made cheese with special bacteria, different kinds of cheese may be produced. Where are the markets for Canadian cheese? Cheddar is the standard Canadian cheese, and is the kind that is exported to Great Britain.

Project.—Write to the Department of Agriculture, Ottawa, for Circular No. 7, N.S. and No. 22, D. and C.S.B., which give directions for making cottage cheese. Cheese of this kind can be made in any home. Try it.

Co-operative Grading and Marketing of Wool.—The wool fibre is covered with minute scales, which impart

strength and lustre to the wool, and which interlock when the fibres are woven into cloth. About one-third of the wool crop of the Western Provinces is now marketed co-operatively by the Canadian Co-operative Wool Growers, Limited. The members of this association send their wool to Lethbridge, Regina, Portage la Prairie, and other centres conveniently located for assembling carload lots. It is then shipped to Weston, Ontario, where it is graded by Dominion Government inspectors. Wool is graded primarily according to the length and fineness of the fibre. There are two main grades—*staple* or wool over $2\frac{1}{2}$ inches long, and *clothing* or wool less than $2\frac{1}{2}$ inches in length. These



Wool fibres. Magnified 300 times.

Courtesy of The Canadian Co-operative Wool Growers, Ltd.

Grading wool from Western Canada at Weston, Ontario.

are subdivided according to fineness, so that there are altogether eleven straight grades. There are also grades for wool which is defective, and all of the grades are divided

into three classes—bright, semi-bright, or dark—according to color and strength. The Canadian Co-operative Wool Growers maintain offices in Boston and London, and the wool handled by this organization is marketed in about equal proportions in Canada, the United States, and Great Britain.

Exercises.—(1) Two animals were auctioned at the same sale. In conformation, color, markings, and condition, there was little to choose between them. Both were pure-bred and both had pedigrees. One sold for $2500, and the other for $250. Account for the great difference in the price of these animals.

(2) Two cows each produce 6000 pounds of milk per year. One cow's milk tests 3.6 per cent and the other 4.8 per cent. How much butter-fat does each produce? Which is the most profitable cow if butter-fat is worth 35 cents per pound? Has the skim milk any value?

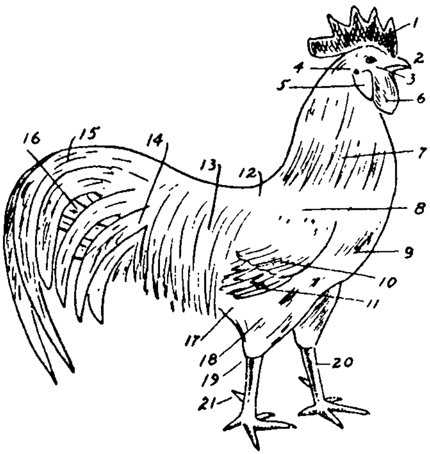
(3) A special grade of milk retails at 20 cents a quart, and has a guaranteed butter-fat content of 5 per cent. The regular grade of milk sells for 13 cents a quart, and has a butter-fat content of 3.5 per cent. In which case does the consumer receive the most butter-fat for his money?

(4) A certain creamery sells a special grade of milk with a butter-fat content of 15 per cent, the price being 26 cents per quart. Does the consumer receive more butter-fat for his money in this case than in the previous exercise? In which case does he receive the most protein and mineral matter?

CHAPTER XIV

FARM ANIMALS (continued)—POULTRY

Classes, Breeds, Varieties, and Types of Chickens.—Chickens are grouped into classes according to place of origin. The classes are divided into breeds on a basis of ancestry, and the breeds are further divided into varieties depending upon the color of the plumage and the kind of combs.



THE POINTS OF A CHICKEN

1. comb.
2. beak.
3. face.
4. ear.
5. ear-lobe.
6. wattle.
7. hackle.
8. shoulder.
9. breast.
10. wing-bar.
11. primary wing feathers.
12. back.
13. saddle feathers.
14. tail coverts.
15. sickles.
16. main tail feathers.
17. fluff.
18. thigh.
19. hock.
20. shank.
21. spurs.

Type as applied to chickens indicates their suitability for a certain purpose. There is the *meat type*, the *general - purpose* or *utility type*, the *egg type*, and the *game type*. Practically no breed is bred to-day for meat production alone, so that a strictly meat-type breed of chickens is hard to find. Such breeds as the Leghorns are primarily egg-type birds and are not suitable for table purposes except as broilers. Then there are a number of general-purpose breeds, such as the

Plymouth Rocks, Wyandottes, Rhode Island Reds, Orpingtons, and others, which produce a plump carcass as well as a good number of eggs.

Key for Identification of Breeds of Chickens*

Type	Class	Breed	Ear-lobes	Legs and Feet	Comb	Color of Eggs	Remarks
Utility type. All clean-legged.	American	Plymouth Rocks	Red	Yellow	Single	Brown	Sitters
		Wyandottes	Red	Yellow	Rose	Brown	Sitters
		Rhode Island Reds	Red	Yellow	Rose or single	Brown	Sitters
	English	Orpingtons	Red	Light or dark	Single	Brown	Sitters
		†Cornish	Red	Yellow	Pea	Brown	Sitters
Egg type. All clean-legged	Mediterranean	Leghorns	White	Yellow	Rose or single	White	Non-sitters
		Minorcas	White	Light or dark	Rose or single	White	Non-sitters
		Anconas	White	Yellow and black (mottled)	Single	White	Non-sitters
	Dutch	Hamburgs	White	Light or dark	Rose	White	Non-sitters
Meat type. All feathered legs.	Asiatic	Brahmas	Red	Yellow	Pea	Brown	Sitters
		Cochins	Red	Yellow	Single	Brown	Sitters
		Langshans	Red	Light or dark	Single	Brown	Sitters

The characteristics of a profitable general-purpose fowl are: short broad head, clear bright eye, deep wide body, legs short and well set apart, breast-bone straight and well covered. There must be a degree of quality about the bird as indicated by the scales of the leg and the alert fine-cut appearance of the head.

*From *Extension Bulletin No. 48, Manitoba,* by M. C. Herner.

†As yet no heavy egg-producing strain of this breed has been developed.

The American Breeds.—The *Plymouth Rocks* are one of the best-known general-purpose breeds. They have single combs, red ear-lobes, and yellow legs, and are bred in barred, white, buff, partridge, and other varieties. The "Barred Rocks" are the most common. These birds are hardy, quick maturing, good meat-producers, and many have high egg records.

Courtesy of The Publications Branch, Winnipeg
A single comb.

The *Wyandottes* have a rose comb, yellow legs, and red ear-lobes. The most common variety is white, but some are silver and golden laced. The Wyandottes are very round or ball-shaped birds, early maturing, and good layers.

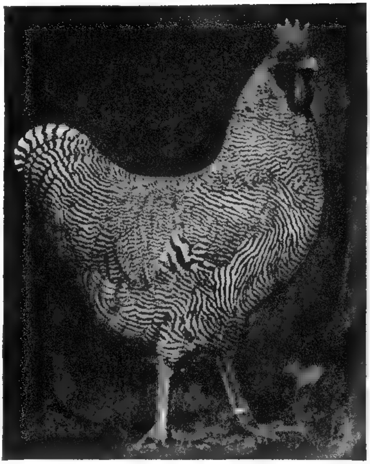
The *Rhode Island Reds* are dark reddish in color. They have rose or single combs, red ear-lobes, yellow or reddish horn-colored legs, and an oblong, straight-backed body. The "Reds" are a good table fowl, a little slow in maturing, and lay quite well.

Courtesy of The Publications Branch, Winnipeg
A rose comb.

These breeds, as well as those discussed later, have been developed by crossing and selection. Unless the poultryman continues to select his breeding stock carefully, his flock will tend to revert to the original types and thus deteriorate in quality.

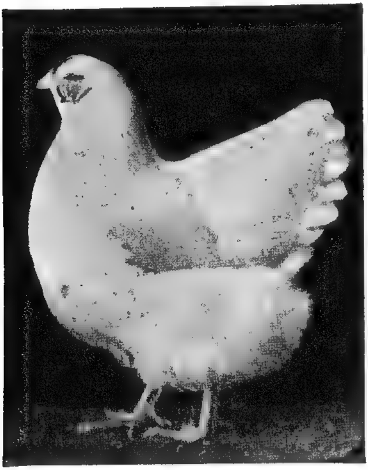
The Asiatic Breeds.—The *Brahmas* and *Langshans* are the most popular of these breeds. Both are large and heavily feathered. In both breeds strains have been

developed with high egg records. They produce large, heavy carcasses, and, although not generally recommended for farm purposes, under certain conditions they give very satisfactory results.



Courtesy of The Publications Branch, Winnipeg
A Barred Plymouth Rock rooster.

The Mediterranean Breeds.—The *Leghorns* are the best-known breed of this class. They are essentially egg-producers, surpassing in general every other breed in this respect, and are found on all large poultry plants where eggs are the chief product. The Leghorns are smaller than the utility hens, more slender in body, and usually very active. They are one of the oldest breeds of hens, originating on the north shore of the Mediterranean Sea. In color they are white, brown, buff, and black. They have single or rose combs, white ear-lobes, and yellow legs. The single-comb white variety seems to be the most popular. Leghorns are hardy, and, because of their quick-



Courtesy of The Publications Branch, Winnipeg
A White Wyandotte hen.

Courtesy of The Publications Branch, Winnipeg
A Rhode Island Red hen.

maturing qualities, the young males are valuable for broiler production.

The English Breeds.—The *Orpingtons.*—Buff and white are the most common colors. They have black or white legs, single combs, and red ear-lobes. The Orpingtons are the heaviest of the utility breeds, hardy, slow maturing, and good layers.

The *Cornish* were developed for fighting purposes. They are poor egg-producers, but their great muscular development makes them very suitable for table purposes.

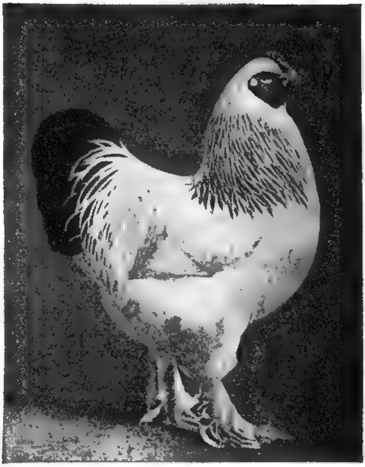
Courtesy of The Publications Branch, Winnipeg
A Black Langshan hen.

Types and Breeds of Other Farm Poultry.—**Ducks.**—There are two common breeds of ducks. The *Pekins* are white in color, wide, deep and long of body, early maturing, and in all respects good farm fowl. The *Rouens* originated in France, and resemble a wild duck in color.

Geese.—The grey *Toulouse* and the white *Embdens* are the two most common breeds.

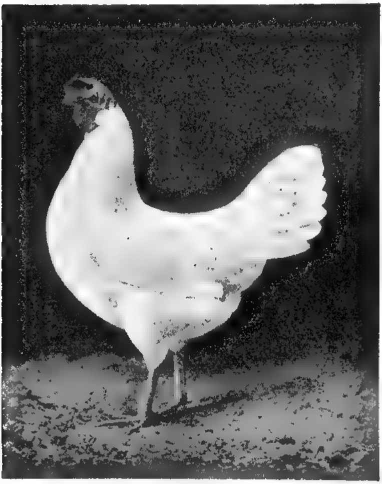
Ducks and geese are raised almost entirely for meat. Size and weight, length, depth, and width of body, early maturity, and quality are the desired characteristics of good birds.

Turkeys.—The turkey industry is rapidly reaching a place of importance in the Prairie Provinces. More turkeys are being marketed every year. The most popular breed is the *Bronze*, a large bronze-colored bird. The *White Hollands* are slightly smaller and less commonly raised. Turkeys should be large in frame and deep in body.



Courtesy of The Publications Branch, Winnipeg

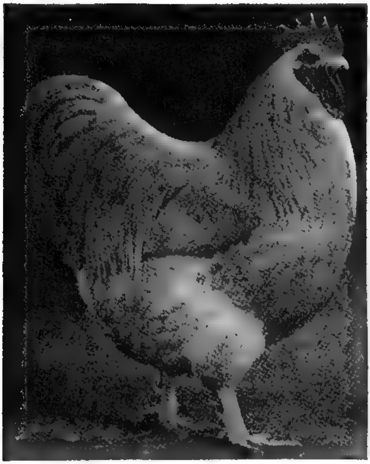
A Light Brahma rooster.



Courtesy of The Publications Branch, Winnipeg

A Single-comb White Leghorn hen.

The Housing of Poultry.—Poultry should not be kept in a warm house. A cool place with plenty of fresh air gives the best results. The essentials of successful poultry-housing are light, good ventilation, dryness, and freedom from draughts. A straw loft is desirable to provide a good circulation of air and to



Courtesy of The Publications Branch, Winnipeg
A Buff Orpington rooster.

absorb moisture. Half of the window space should be glass and the other half factory cotton, arranged in alternate sections. 1 square foot of window to every 10 square feet of floor space will supply the necessary amount of light. Provision for the opening of at least half the windows during the summer months is advisable. The windows should be in the front of the house, facing the runs, which are best located on the south side. Roosts are built at the back and north. The best floor is made of wood or earth, covered with about 6 inches of cut straw. Cement floors afford the best protection against rats, etc., but are liable to be too cold and damp in this country, unless kept well covered with a deep layer of litter. Drinking pans, feed hoppers, and grit and oyster-shell boxes are placed along the wall. The nests may be located below the dropping board beneath the roosts. They should be

Courtesy of The Publications Branch, Winnipeg
A Rouen duck.

off the floor, and arranged so that the hens enter from the back. If the nests and the roosts are built in sections, they can be removed from the house from time to time, washed, disinfected, and aired. There should be plenty of room for scratching and exercise. Each hen requires about $4\frac{1}{2}$ square feet of floor space. The house must be kept clean at all times, and it is a good plan to whitewash the interior frequently. Once a week the house should be thoroughly sprayed with a disinfectant, such as a teaspoonful of creoline in a pint of coal oil.

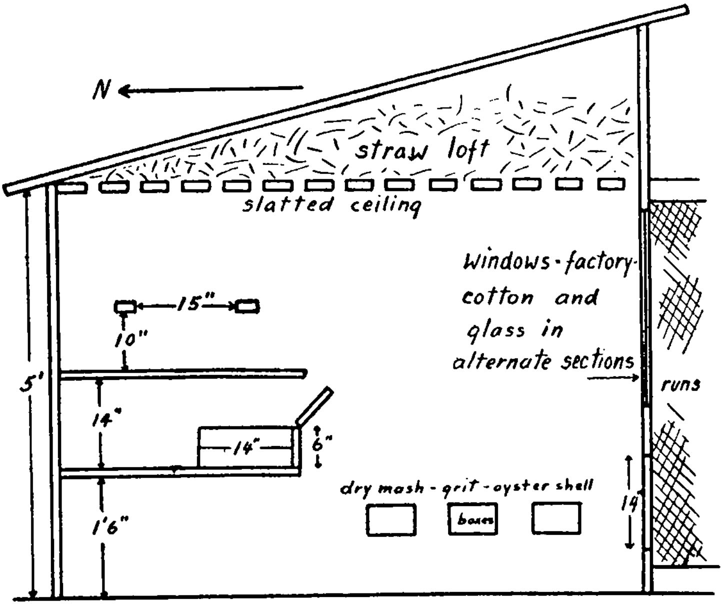
Courtesy of The Publications Branch, Winnipeg
A Toulouse goose.

Courtesy of The Publications Branch, Winnipeg
A Bronze turkey.

The Care and Feeding of Hens.—Like other classes of live stock, hens must be fed suitable rations to produce profitable results. The needs of the laying hen are entirely different from the requirements of poultry being fattened.

Laying hens. —During the summer, when hens are on free range on the farm, they practically balance

their own ration. What is a *balanced ration*? When the weather makes it necessary to shut them in-doors, feeds similar to those that they pick up for themselves during the summer months must be provided. Variety is required. A scratch feed, consisting of equal parts of whole wheat, barley, and oats, should be scattered in the litter on the floor twice



A plan of a poultry house. (Draw.)

a day, at the rate of a handful to every two birds. Why in the litter? To encourage egg production nothing excels a dry mash, composed of equal parts of oat chop and bran or shorts with a small amount of charcoal, and kept before the hens at all times. A substitute for grass is necessary. For this purpose alfalfa, cabbage, turnips, mangels, or sprouted oats are supplied—about 3 pounds per day for

100 hens. Skim milk or buttermilk and meat scrap will supply the protein required for egg production. A soft mash of chop, bran, or shorts, and table scraps should be fed once a day. A gallon is sufficient for 100 birds. Drinking water, grit for digestion, and oyster-shell for shell-making must always be available to the hens.

Fresh air without draughts, exercise, cleanliness, and dryness are essential. Lighting the poultry house by means of electric light from 7 a.m. to daylight and from dusk to 10.30 p.m. has been found to encourage greater egg production and thus to increase the profits from hens during the winter months.

Fattening poultry.—This process should start in the late summer or early fall, when the poultry are four or five months old. The birds are thoroughly dusted with insect powder, and confined in slatted crates. They are starved for twenty-four hours, then fed lightly on a mash consisting of equal parts of ground oats, wheat, and barley mixed with skim milk or buttermilk to a fairly stiff consistency. Gradually the amount is increased until the birds are being given all that they will clean up in fifteen or twenty minutes morning and evening. When ready for market, chickens should weigh at least 5 pounds each.

Managing a Flock of Hens.—Culling out the Poor Layers.—Proper feeding, of course, is essential. Pure-bred males of high quality are necessary to maintain the standard of the flock. When the breeding season is over, the males should be separated from the hens and, unless quite valuable, killed for table use. Infertile eggs will keep much better. The hens must be healthy, vigorous birds of good type.

Numbered leg-bands can be used to identify the individuals of the flock, and trap-nests will show which hens are actually laying the most eggs. The trap-nest prevents the escape of the hen until the poultryman is able to record the

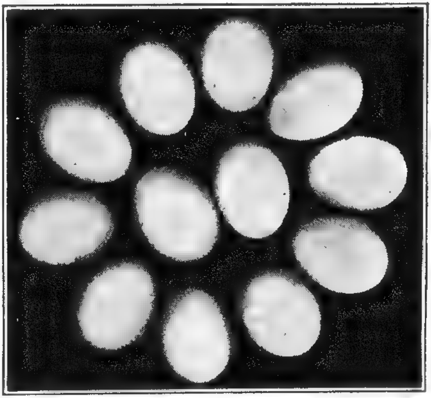
number of the leg-band. In trap-nesting the eggs must be gathered frequently and regularly, and a record kept of each hen. *The profitable hen will lay heavily during the winter, when eggs are high-priced.* The egg-producing ability of the hen may be determined also by a physical examination. The best time to cull is the latter part of August and the first weeks of September. The following is a comparison of the characteristics of good and poor layers.

Culling Chart*

Good layers have		Poor layers have
moist large white	Vent	dry small yellow
white	Legs	yellow
far apart thin	Pelvic bones	close together thick
large deep soft thin skin	Abdomen	small shallow hard thick skin
large bright waxy plump	Comb	small dull dry shrivelled
fine lean clean cut	Head	coarse fat wrinkled
bright full bulging large oval	Eye	dull sunken flat small round
faded	Eye-ring	yellow
pale	Beak	yellow
white	Ear-lobe	yellow
thin fine loose	Skin	thick coarse tight

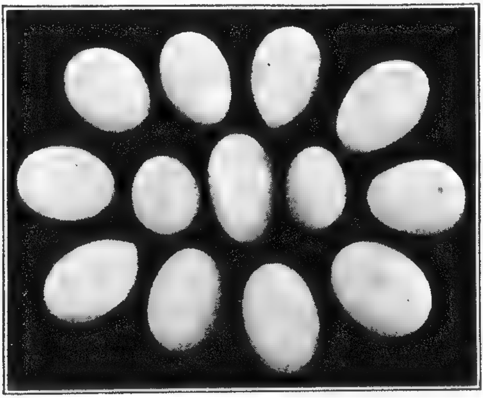
Incubation.—For hatching purposes *eggs* selected should be large and uniform in size, of good shape, and as fresh as possible. Eggs that have been chilled, or are dirty or abnormally shaped, will not give satisfactory results.

*From *Ex. Bulletin No. 63, Manitoba,* by M. C. Herner.



Eggs suitable for hatching.

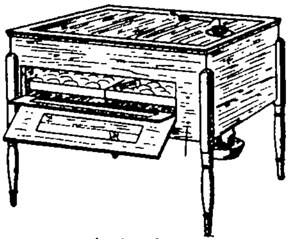
Hens that are inclined to be broody are dusted with insect powder, and placed in nests for a day or two before given eggs. The nests should be about 12 by 16 inches in size. A piece of sod is placed in the bottom, and the nest shaped by straw or grass around the sides. Everything about the nesting place must be dry and clean. When it is found that the hen is going to sit, from 12 to 14 eggs are placed under her. Once daily each hen must be taken from the nest for feed, exercise, and a dust bath, but at all other times must be left undisturbed as much as possible. A couple of days before the eggs hatch, the hen should be again dusted with insect powder.



Eggs unsuitable for hatching. Why?

When 100 or more chicks are raised each year, an *incubator* will prove more satisfactory than hens, especially if early hatched chickens are desired. From 100 to over 2000 eggs may be set at one time depending upon the size of the incubator.

A temperature of 103° F. is maintained by a lamp below the egg-chamber. A moisture pan, which must be kept filled with water, prevents too dry an atmosphere. Ventilation is essential. After the second day the eggs must be turned morning and evening, and after the tenth day provision must be made to cool the eggs once daily. A full set of directions is furnished by the manufacturer with each incubator, and it is a good plan to follow these instructions closely.

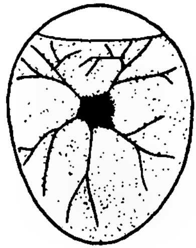


An incubator.

Eggs under a hen or in an incubator should be *tested by candling* on the seventh and fifteenth days, and infertile or spoiled eggs removed.

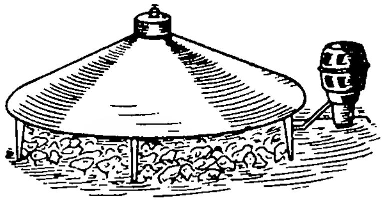
The *periods of incubation* for the more common species of farm poultry are: chicken, 21 days: duck and turkey. 28 days; goose, 30 days.

Rearing Chicks.—Chicks will require no feed for the first two days. For the first week or ten days stale bread soaked in milk, pressed dry and mixed with hard-boiled egg, forms a good ration. A dry mash consisting of equal parts of fine oat chop and shorts with a small amount of beef scrap, charcoal, and grit should be available to the chicks at all times from the beginning. After the first two weeks supply whole grain, beginning with 2 parts good feed wheat and 1 part finely cracked corn, and gradually change to whole grain. The chicks will grow better if given buttermilk or skim milk to drink. Why? Exercise, warmth, cleanliness, and shade



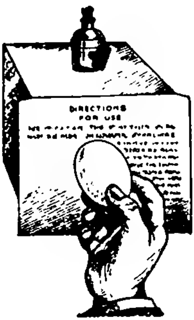
A fertile egg on the seventh day, as it appears when candled. Notice the veins and the large air space. (Draw.)

are absolutely essential for growing poultry. Heat is especially important during the first few weeks. A pasture of alfalfa or grass is desirable to supply green feed. Write for the bulletin *Brooding and Rearing of Chicks*, Ex. Cir. 13, Department of Agriculture, Ottawa.



An oil-heated colony hover for young chicks.

The Care and Feeding of Ducks and Geese.—Like chickens, ducks and geese do best in clean, dry surroundings. No water is necessary except what they require for drinking. A good range to provide exercise is essential. Shorts, corn meal, and ground oats are desirable in the ration, which should also include green feeds, such as lettuce, leaves, etc., meat scraps, milk, and grit. The young fowl should be fed four or five times a day for the first few days. All grain fed should be ground, as geese particularly cannot make good use of these feeds whole or cracked.

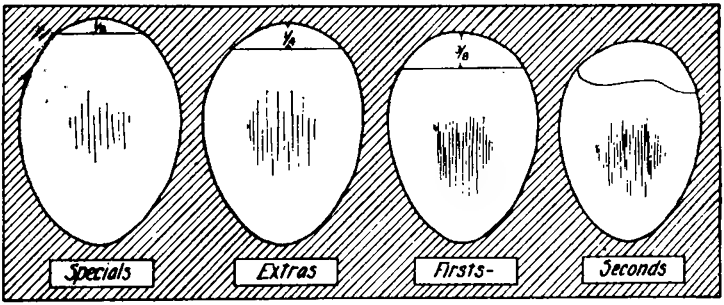


An egg-candling appliance. This appliance and one suitable for use with a kerosene lamp are distributed free by the Poultry Division of the Livestock Branch, Ottawa.

The Care and Feeding of Turkeys.—Young turkeys are delicate for the first few weeks, and must be carefully protected from dampness and lice. They should be fed frequently. The ration may consist of stale bread soaked in milk and then pressed dry, and chopped hard-boiled eggs. Gradually shorts are substituted for the bread and eggs until the entire ration is composed of shorts and milk. In a few days some cracked grain should be fed in the litter. Green feed, fresh water, charcoal, and grit are necessary at all times. After about four

weeks, the turkeys may be allowed to roam at large, and will then pick up most of their rations, one feed of shorts and a little wheat a day being all that they will require to be fed until the time comes to fatten them for market.

NOTE.—For further information about the feeding and care of ducks, geese, and turkeys, send to the Poultry Division, Department of Agriculture, Ottawa, for the following bulletins: *Duck Raising*, Ex. Cir. 29; *The Management of Geese*, Ex. Cir. 31; *The Care and Management of Turkeys*, Ex. Cir. 30, and Bulletin 46, N. S.



Canadian grades of fresh eggs. (Draw.)

The Marketing of Eggs and Poultry.—All eggs must, by law, be candled by merchants before being sold to the consumer. The process consists of holding the eggs before a light enclosed in a special device in a darkened room. By this means the contents of the egg become fairly visible. The classes and grades of market eggs are as follows:

Classes	**Grades**
Fresh	Specials, Extras, Firsts, Seconds.
Storage	Extras, Firsts, Seconds.
Preserved	Extras, Firsts, Seconds.
Cracked and Dirties	Not Graded.

Definition of Eggs in Fresh Class

Specials—25 ounces per dozen, clean, shells sound, air-space not over $\frac{1}{8}$ inch deep, white firm and clear, yolk dimly visible.

Extras—24 ounces per dozen, reasonably clean, sound in shell, air-space not over $\frac{1}{4}$ inch, white firm, yolk slightly visible.

Firsts—22½ ounces per dozen, reasonably clean, sound in shell, air-space less than $\frac{3}{8}$ inch, white slightly tremulous, yolk may be distinctly visible but moving freely.

Seconds—sound in shell, may be weak or watery, heavy yolks, and all other eggs fit for food.

Eggs should be shipped in strong, clean cases, using good fillers and flats. An even layer of excelsior is placed under the first flat and on top of the upper flat. Fasten the lid on securely. Cases must be marked "Ungraded eggs for shipment only", unless going direct to the consumer.

Poultry should be starved for twenty-four hours or longer before being killed. When the digestive system is empty, the carcasses keep better. Killing is accomplished by inserting a sharp knife into the mouth, cutting the jugular vein, then piercing the brain. Each bird should be plucked dry immediately. The head is then neatly wrapped. Birds should not be drawn, and feet and legs must not be removed. If the skin is unbroken, there is less danger of spoiling. Before being shipped, dressed poultry should be thoroughly chilled to a temperature of 32° to 40° F. depending upon the distance that they are being sent.

Egg and Poultry Pools.—"Pools" are now marketing a large percentage of these products in Western Canada. In principle these co-operative efforts correspond to the Wheat Pool.

Exercises.—(1) If there is an Egg and Poultry Pool in your district, have one of the directors explain its operation to you.

(2) How will the price received by one member of a Pool compare with the price received by other members for the same grade of eggs or poultry?

(3) Will the establishment of collecting centres and the shipping of eggs and poultry in large quantities reduce the shipping cost per dozen and per bird? Explain.

(4) Should the consumers profit by the operations of a "Pool"? In what way?

(5) By reference to the discussion of "Co-operative Marketing" on page 266 and the "Wheat Pool" on page 277, make a summary of the advantages of an Egg and Poultry Pool.

One of the big advantages of a Pool for the marketing of poultry products is that cold storage facilities are made available to the small producer. The Pools, by building cold storage plants, are able to gather up surplus supplies during the seasons of heavy production and dispose of them later. In this way the flooding of the market, and hence a disastrous drop in price, is prevented.

Egg-laying Contests.—Registered Pedigree Poultry.—The Poultry Division, Experimental Farms, Ottawa, periodically conducts egg-laying competitions at Brandon, Indian Head, Lethbridge, and other points throughout the Dominion. Hens, to be eligible to compete in any of the Canadian National Egg-laying Contests, must have been bred and raised by the contestant. Entries are shipped to one of the above places and remain there during the contest. The object of these competitions is to encourage the breeding of hens of greater production, to furnish reliable information about them, and to provide a system of qualification for the registration of poultry. Hens that conform to the standard of the breed and lay in a contest a minimum of 200 eggs, weighing at least 24 ounces to the dozen, and males free from breed disqualifications and bred from a dam and granddam of the foregoing qualifications, may be registered in the Canadian Livestock Records Association.

Exercises.—(1) By what special characteristics would you distinguish between the following breeds of chickens: White Plymouth Rocks, White Wyandottes, White Orpingtons, and White Leghorns?

(2) Write to the Poultry Division of the Livestock Branch, Ottawa, for bulletins on the methods and appliances for candling eggs.

Ask also for a colored chart showing the Canadian Egg Standards. Construct an apparatus and examine a number of eggs.

(3) Candle the eggs sold from home to prevent bad ones being shipped off the farm.

(4) Other bulletins dealing with any phase of the poultry industry in which you may be interested can be secured by writing to the Poultry Division, Livestock Branch, Ottawa.

(5) For purposes of judging poultry, every school should have a copy of *The American Standard of Perfection*, published by the American Poultry Association, Fort Wayne, Indiana, and of *Profitable Culling and Selective Flock Breeding* by Jackson and Curtis, published by the Reliable Poultry Journal Publishing Company, Dayton, Ohio.

Project.—Write to the Department of Agriculture or the Agricultural College in your province for advice and assistance in culling out the poor layers and make a determined effort to improve the flock at home.

CHAPTER XV

FARM MANAGEMENT—PART ONE

The term "farm management" refers to the business side of farming. The farmer or farm manager must study very carefully the problems of his farm and all the information which he can find about them, in order to know whether or not he is doing "the right thing at the right time and in the right way".

There are numerous details which he must continually examine to prevent losses which would reduce his profits. He must know definitely the most profitable crops or live stock to produce, how much of each to invest in, and the method by which they can be marketed to bring him the greatest returns. The plan and location of his buildings, the shape and arrangement of his fields, the fertility of his soil, and the direction of his labor demand his constant attention.

As farmers more and more make a real business of farming, it will be necessary for them to have more definite knowledge of the cost of growing crops, of feeding live stock, of transportation, and of marketing. These are the problems which the students of farm management seek to solve in order to make farming a less hazardous and more profitable business.

We have already discussed many phases of farm management, such as the management of the soil, the destruction of weeds and insect pests, the prevention of plant diseases, the production of crops and live stock, etc. There remain such questions as the planning of the farm, the keeping of farm accounts, the cost of production, the methods of

marketing farm produce, and other conditions that affect the welfare of the farming industry. These will be considered in the following pages.

Farm Accounts or Bookkeeping.—Inventories.—If the business of farming is to be conducted efficiently, some system of accounting must be adopted. The method followed should be as simple as the size of the farm will permit, so that as little time as possible will be required to make entries and arrive at balances. There are two common systems in use: (*a*) The single entry system, in which each item is entered in but one account. For example, if the farmer sells a horse, he makes an entry of the transaction merely in the horse account. (*b*) The double entry system, in which each item is recorded in two accounts. For example, the record of the foregoing horse sale would be entered in the horse account and also in the cash account. In this way a double check is kept on each transaction, but the double entry system requires more time than the average farmer can spend on his books.

To the farmer the advantages of keeping books are as follows: He knows, at any time, his exact financial standing. At the end of each year it is possible to determine what it has cost to produce his crops and to feed his live stock, and he is therefore in a position to know which of his farm enterprises are profitable or otherwise.

When accounts are to be kept, the following procedure may be followed:

(1) Take an *inventory* of the capital, stock, and equipment of the farm, together with bills payable and bills receivable. Each item of the farm is listed, and a value is placed upon it. Value should be estimated at market prices, that is the price which the article would bring if offered for sale. When totalled, and after the liabilities, if any, have been subtracted from the assets, the inventory

should show the farmer his *net worth* or, in other words, exactly what he is worth financially.

Sample of a Farm Inventory

Inventory 320 acres December 31st, 1925.

	Quantity	Value per unit	Valuation
Real Estate			
Land	320	$40.00	$12,800.00
Improvements (house, barns, fences, etc.)			5,200.00
Total			$18,000.00
Live Stock			
Cows	3	$ 60.00	180.00
Horses	10	110.00	1,100.00
Pigs (breeding sows)	2	20.00	40.00
Poultry	52	0.50	26.00
Total			$1,346.00
Machinery and Tools			
Plows	2	$125.00	250.00
Drag harrows	1	25.00	25.00
Disc	1	85.00	85.00
Drill	1	200.00	200.00
Binder	1	195.00	195.00
(All other items, such as mower, rake, wagons, sleighs, fanning mill, tools, are listed, but not shown here)			610.00
Total			$1,365.00

Sample of a Farm Inventory—*Continued.*

Inventory	320 acres	December 31st, 1925.	
	Quantity	Value per unit	Valuation
Farm Produce			
Wheat........................	400 bu.	$1.40	560.00
Oats........................	950 bu.	.40	380.00
Hay........................	25 tons	12.00	300.00
Total...........			$1,240.00
Accounts Receivable			
Harry Jones' note for team of horses....................			100.00
Cash on hand and in Bank........			300.00
Total Value of Assets (property owned)......................			$22,351.00
Accounts Payable			
Mortgage on farm.............			2,000.00
Massey-Harris Co. Machinery..			200.00
Total Liabilities (amounts owed)...			$2,200.00
Net Worth or Balance of Assets over Liabilities....................			$20,151.00

When arriving at an estimate of the value of the assets of the farm, allowance must be made each year for *depreciation,* because buildings, machinery, etc., wear out. A general rule is to calculate depreciation on buildings at 5 per cent per annum and on machinery at 5 to 10 per cent. Depreciation, of course, will vary a great deal on different farms.

(2) Decide upon the accounts to be kept. The following have been suggested: a cash account, an account for bills receivable, another for bills payable, a separate account for each class of live stock, for each crop or other enterprise that may be engaged in, a record of man and horse labor, a record of feed consumed, and possibly a general account to take care of items not provided for above. All labor items should be entered in the labor record, indicating in which department they were employed, and transferred at the end of the year to that department. In a similar manner all feed used is accounted for in the general feed record, and charged at the end of the year to the account of the live stock that consumed it.

(3) To open the accounts secure a suitable book and apportion space in it to each account. Enter values shown in the inventory in each account on the debit or expense side, except bills payable. Why?

(4) Post or enter current entries from day to day as they arise.

(5) To close the books take an inventory, and this time credit each account, except bills payable. Charge labor and feed to the proper accounts. If feed items are from crop accounts, the crop accounts must be given credit for the item when it is transferred. Charge each account with taxes, interest on money invested, etc. Balance each account to show profit or loss.

(6) Total the gains and losses from the individual accounts, and determine the total profit or loss for the entire farm business.

Accounts, to be accurate and valuable, must be neat. It is a good plan to carry a small note-book at all times and to enter in this the various items as they occur. At the end of the day the items should be posted in the regular account book.

Sample Account No. 1

1925	Horses	Dr.	Cr.
Jan. 1.	As per Inventory..............	$1100.00	
Jan. 15.	To Prince shod.................	3.00	
Feb. 3.	Sold team (Jack and Jim)........		220.00
Apr. 10.	To Veterinary Fees..	2.50	
Oct. 25.	Sold 3-yr.-old colt.......		110.00
Dec. 31.	To Oats (630 bu. @ 34c.) (from Feed Acct.).................	214.20	
	To Hay (25 tons @ $6.00) (from Feed Acct.)	150.00	
	To Man Labor (from Labor Acct.)	175.68	
	To Horse Labor(from LaborAcct.)	45.60	
	To Int. at 6% on Capital Invested	66.00	
	To Shelter....................	40.00	
	By HorseLabor(from Labor Acct.)		500.00
	As per Inventory		770.00
	Loss.......		196.98
		$1796.98	$1796.98

Exercises.—(1) Make an inventory of the articles in the schoolroom or in a room at home. List each article of furniture, etc., separately and give it a value.

(2) The following is a partial summary of some of the changes which occurred during 1926 in the financial standing of the owner of the farm for which the 1925 inventory is given on page 254.

Feb. 3. Sold team of horses $220.00.
Apr. 18. Sold 100 bu. of wheat at $1.50 per bu.
May 6. Bought 150 bu. of barley for feed at 50c. per bu.
May 26. Jones paid note of $100.00 for horses, in full.
June 16. Bought a milk cow at $65 *to replace one that died.*
Oct. 25. Sold a 3-year-old colt $110.00.
Nov. 5. Sold 12 spring pigs $20.00 each.
Nov. 15. Paid Massey-Harris note of $200.00 in full.
Dec. 30. Paid $500.00 on principal of mortgage.
During the year the two sows increased in value $10.00 each.
Depreciation on machinery—10% on total value.

There was on hand Dec. 31— 300 bu. of wheat @ \$1.25
1025 bu. of oats @ .35c.
30 tons of hay @ \$10.00

Other transactions, such as the sale of the 1925 crop, money spent, etc., leave a balance of \$500.00, to or from which the cash received or paid out in the foregoing transactions must be added or subtracted to calculate the cash balance in the bank at the end of the year 1926. The value of the land and buildings, the number and value of the live stock, etc., remain the same except where indicated above.

Make out an inventory for Dec. 31st, 1926, and determine the change in the farmer's net worth.

(3) A dairy cow was purchased in 1918 for \$85.00. In 1925 she was sold for meat for \$37.50. Find the average annual rate of depreciation.

(4) Post the entries in the following account, determine profit or loss, and balance the account.

As per inventory—5 cows @ \$100.00 each—Dec. 31, 1924.
Each cow averaged 30 pounds of milk per day for 300 days.
Milk tests 4% butter-fat which is sold for 35c. per pound.
5 calves were born—2 were sold for \$10.00 each; the other 3 were kept and on December 31st, 1925, were worth \$20.00 each.
Feed account shows each cow consumed feed worth \$37.10.
Labor account shows $\frac{1}{3}$ hour per day man labor valued at 18c. per hour for 365 days. Interest charged at 6%.
Shelter \$5.00 each cow. Pasture \$20.00 for 5 cows.

NOTE.—Besides the above, the cow account should be charged with depreciation on dairy machinery used and with the cost of hauling the milk to town, but leave these out and use the foregoing items only.

(5) See *Farm Machinery* for problems on depreciation of farm implements.

The Cost of Production.—Profit in Farming.—Every farmer should know exactly what it costs him to produce his crops, live stock, and other products. In order to do this, accurate accounts must be kept. From these records it is possible to determine the number of horses and men required to perform the various operations of the farm, to

calculate the cost of these per hour, to estimate the length of time required to prepare an acre for seed, to harvest the crop, to feed and care for the live stock, and the other items necessary in preparing statements of production costs.

Sample Account No. 2

1925	Wheat (100 acres of fall plowing)	Dr.	Cr.
	To Plowing	$ 275.00	
	To Harrowing	50.00	
	To Seed (125 bu. @ $1.50)	187.50	
	To Cleaning and Pickling	15.00	
	To Seeding	50.00	
	To Harrowing after seeding	25.00	
	To Harvesting—cutting	110.00	
	stooking	40.00	
	twine	40.00	
Sep. 12	To Threshing (2000 bu. @ 12c.)	240.00	
	To Depreciation on machinery	70.00	
	To Rent—(Interest on money invested in land)	240.00	
	(Taxes)	60.00	
	To Insurance	60.00	
Oct. 15	To Hauling to railway (5c. per bu.) (depends on distance)	100.00	
Nov. 2	To Handling charges at elevator 2½c. per bu.)	50.00	
Nov. 2	To Freight (20c. per 100 lb.)	240.00	
Nov. 2	To Commission (1c. per bu.)	20.00	
Nov. 2	To Weighing—inspection	2.00	
Nov. 2	By 2000 bu. at $1.50 (spot price)		3000.00
	Profit	1125.50	
		$3000.00	$3000.00

It is very difficult to present any definite information on the cost of production. So much depends upon local

conditions that methods employed, cost of feed, etc., vary a great deal in different localities. The best that we can do is to indicate the procedure usually followed in arriving at various costs. Each operation or expense should be listed as follows:

The Cost of Producing an Acre of Wheat

Cultivation—plowing	$2.75	
harrowing	.50	$ 3.25
Seed		2.00
Cleaning and pickling seed		.15
Seeding		.50
Harrowing after seeding		.25
Harvesting—cutting	$1.10	
stooking	.40	
twine	.40	1.90
Threshing		2.40
Depreciation on machinery		.70
Interest on money invested in land		3.20
Taxes		.90
Insurance		.60
		$15.85

The cost per bushel could be arrived at by dividing the acre cost by the yield, but the yield varies so much from year to year that the acre cost appears to be most important, since it costs as much for plowing, seeding, etc., and for taxes, insurance, and interest charges for a few bushels as for a 20 or more bushel crop.

The Cost of Fattening a Steer

Feed—at an average of 11.35c. per day for 165 days	$18.72
Man labor, $\frac{1}{4}$ hour per day at 18.3c. per hour	7.53
Shelter	1.00
Interest on money invested—8% of $27.00	2.16
Total	$29.41

The Cost of Fattening a Steer—*Continued.*

Ration used:

15 lb. silage at	.25c.	3.75c.
10 lb. roughage at	.125c.	1.25c.
3 lb. barley at	1.00c.	3.00c.
2 lb. oats at	1.00c.	2.00c.
1 lb. bran at	1.35c.	1.35c.
	Total	11.35c.

The total cost of this steer may be arrived at as follows:

Buying price of 900 lb. steer in fall at 3c.	$27.00
Cost of care and feed	29.41
Total	$56.41

Steer should gain in 165 days at 1.5 lb. per day—247.5 lb.
Selling price of 1147.5 lb. steer in spring at 6.5c.—$74.58.

The *profit* in all farming operations or the *net return* to the farmer is determined by deducting from the receipts all expenses and a fair rate of interest on invested capital. *The personal expenses of the farmer and his household must not be charged against the farm business.*

Exercises.—(1) Ask experienced farmers how many acres can be plowed, harrowed, seeded, cut, and stooked per day. What does it cost them to perform these operations? What does it cost to clean and pickle wheat for seed? What does it cost per acre to stook the crop in your locality? How much twine is required per acre, and what is it worth per pound? What is the price per bushel for threshing wheat, oats, and other grains? Find the interest on the money invested in an acre of land. What are the taxes per acre? When each member of the class has secured as accurate information as possible, average the results, and estimate the cost of producing an acre of grain in your district.

(2) In the example regarding the steer, above, calculate the cost of producing 1 lb. of beef if the steer dressed out 60 per cent when slaughtered. Your answer will, of course, be the cost on the farm, because the $74.58 does not include freight or other market costs.

(3) A binder costs $284. The annual charge against it is interest

at 6 per cent, depreciation 10 per cent, and shelter 75c. Find the cost per acre if 200 acres are cut. Repairs, of course, would add to this. What is the cost per acre the second year? What should the binder sell for at the end of the second year?

(4) A barn is worth $3000. It shelters 18 horses and 35 cows. Calculate the annual cost of shelter per head, allowing the following charges against the barn: 5 per cent for depreciation, 6 per cent for interest, ½ per cent insurance, $20 for repairs.

Farm Labor.—The profitable employment of labor is one of the most troublesome problems with which the farmer-manager is called upon to deal. He must use sound judgment in selecting his help and in directing them in order to avoid waste of time and effort. Study Exercise No. 3 very carefully. The most economical employment of labor demands a farming system that distributes the work involved evenly throughout the entire year. Such necessary labor as chores, repairing fences, painting, etc., must be arranged for, but should be reduced to a minimum. A rotation of crops must be planned that will employ the help uniformly at all periods of the growing season. When the crop requires less attention, other profitable enterprises, such as the feeding of beef cattle or the cleaning of seed, should be undertaken.

The farmer who is able to plan his work to keep a minimum number of men uniformly busy the year around will see many advantages in this arrangement. It will be possible for him to employ men for longer periods. In this way a better class of help is available. Transient laborers are usually not as efficient or dependable as men seeking permanent employment; and it is not always possible to secure extra help when required during busy seasons. The man who has become familiar with the methods employed, the location of the fields, etc., of a particular farm, is more valuable to that farm than the stranger unacquainted with these things.

Calculate the cost of man labor per hour as follows:

Wages per month (30 days)	$35.00
Board and room per month	20.00
Total	$55.00

10 hours per day for 30 days—300 hours.
Cost per hour—$55.00 ÷ 300 = 18.3 cents.

Like man labor, horse labor must be planned to keep a minimum number of horses uniformly at work throughout the year. More money is often lost by feeding horses standing idle in the stable than by making poor bargains when buying or selling them. Calculate the annual cost of stabling and feeding the work horses on the farm.

Cost of Keeping a Horse for One Year

Feed—	
12 lb. oats per day for 240 days @ 1c. per lb.	$16.80
8 lb. oats per day for 125 days @ 1c. per lb.	10.00
3 tons hay @ $6 per ton	18.00
Man labor—$\frac{1}{2}$ hr. per day for 240 days @ 18.3c.	21.96
Man labor—$\frac{1}{4}$ hr. per day for 125 days @ 18.3c.	5.70
Shelter	5.00
Interest at 6% on money invested	6.00
Total	$83.46

A careful record should be kept of all the work performed by the horses. This should then be credited to the horse account at the end of the year.

All labor expenses must be charged against the department of the farm in which labor has been employed.

Exercises.—(1) Make careful inquiries about the cost of board and room in your locality. Find out what the farmers are paying for their hired men. Using the information which the class has gathered, calculate the average cost per month of farm labor in your district.

(2) Keep a record for a week of the number of hours of work done by each man on the farm, that is, from Monday morning until the

following Sunday night. Using this information, calculate the cost of man labor per hour on the farm.

(3) A Dominion Experimental Farm test showed that an acre of land manured yielded 56.7 bushels of wheat as compared with 50 bushels from an unmanured acre. The amount of manure applied was 12 tons. (*Seasonable Hints Report.*) If it takes a man and a team 3 days to haul and spread the manure and the team costs 20c. per hour and the man a like amount, does the increase in yield pay the cost of manuring the field? Take the price of wheat at $1.25 per bushel.

The last problem illustrates the fact that labor on the farm may be readily misdirected. There is no doubt that all the manure produced on the farm should be returned to the fields, but the work should be performed during a slack season when there is little else to be done.

CHAPTER XVI

FARM MANAGEMENT—PART TWO

Marketing of Farm Produce.—The problem of marketing is one of the greatest confronting the farmer. The profits from his finest crops or live stock may be very greatly reduced by unwise marketing.

Exercise.—After the crop is harvested and threshed, there are many expenses to be met before it is finally disposed of. Estimate some of these, as follows:

The grain must be hauled to a railroad. If a man and team are worth 40c. per hour and the team travels $2\frac{1}{2}$ miles per hour with a load of 80 bushels, find the cost per bushel of hauling grain from a farm 5 miles from the railroad, and from a farm 15 miles away.

At the elevator a charge is made for loading the grain. Appoint a committee from the class to visit the elevator to ascertain this charge per bushel.

The railroad collects a freight charge for hauling the grain to the terminal elevator. Another committee should learn the rate from the local station agent. Is the grain from your district shipped to Vancouver or to the head of the Lakes?

A commission agent or the Wheat Pool will make a charge for selling the grain. Information regarding this charge may be secured from a farmer.

When each of these charges has been found, calculate the total cost of marketing a bushel and a carload of wheat.

The marketing of live stock incurs similar expenses. There is freight to pay. When the stock arrives at its destination, it must be unloaded, put into special pens, and fed and watered, for all of which the farmer must pay.

Besides the expense of marketing, there is also the question of price. If the farm produce is disposed of at the

wrong time, a lower and perhaps unprofitable price must be accepted.

You will realize how readily mistakes in marketing will change profits into losses. This phase of farm management is very important. Every farmer must study very carefully the most economical methods of disposing of his grain, live stock, garden crops, etc., and must know exactly the time of year when the demand for his products will be the greatest, and the price therefore the most profitable.

Co-operation in Selling and Buying.—In order to reduce the cost of marketing, many producers are now disposing

A section of the Southern Saskatchewan Co-operative Stock Yards, Moose Jaw.

of their grain, live stock, etc., co-operatively rather than individually. There is probably a co-operative association or a local of a Pool in your district, and an effort should be made to have an officer of one of these organizations tell the class of the advantages of working together.

One of the biggest advantages of selling co-operatively is that the expense per individual is very much less. For example: each of four farmers has five steers to sell. To ship these to market separately each farmer would be obliged to pay freight on a whole car. But if they agree to ship co-operatively, the twenty head of cattle would be forwarded in one car, and each farmer required to bear but a quarter

of the expense. The same principle may also be applied to the purchasing of supplies for the farm. A carload of apples could be brought into a district and distributed to the farmers much more economically than the farmers could purchase their apples individually from the local dealer.

When the farmers of a district decide to co-operate, they usually organize a co-operative association. A president and other officers are elected, and a manager, who understands the work to be undertaken, is appointed. An association that is truly co-operative makes no profit for itself, but returns all earnings to the members in proportion to the business which each has conducted through the association. Expenses are met by a charge upon the members, this charge being the same per unit, irrespective of the volume of business which each has contributed. For instance—if the association disposes of twenty head of cattle and one of the members has one steer in the shipment, his share of the expense would be one-twentieth of the total, while a man with five steers in the lot would be required to pay one-quarter of the cost. To be most successful the association must see that produce, such as eggs, dressed poultry, butter, etc., offered for sale, is of the highest quality and presented to prospective purchasers in as attractive a manner as possible. By paying attention to these things an association may establish a reputation for its goods and develop a wider and more permanent market for what it has to sell.

The advantages of co-operation may be briefly summed up as follows: A true co-operative association seeks to sell to the consumer, thus eliminating the middle man; the total value of the produce sold, less handling expenses only, is in this way returned to the producer; in buying, the purchaser goes direct to the producer and receives full value for all money spent. Produce sold co-operatively is usually in

such quantity (carload lots, etc.) that higher prices are commanded; in the purchasing of large quantities a lower price can often be secured. The handling expense per unit in buying or selling co-operatively is usually much lower than the individual farmer could manage; the man with the small amount of produce to sell can handle his goods at the same rate per unit as the man with a large quantity; when several farmers unite to make up a large shipment, the cost per unit is reduced to a minimum, and better shipping facilities can usually be secured. A well-organized co-operative association is able to afford the expense of a paid expert to direct its operations. By co-operation the quality of the produce of a district can be raised and *standardized* so that, when placed upon the market, a better price is obtained.

For example: You are a butter-dealer and buy a large quantity from a certain district. The butter offered to you by the various farmers in this district varies a great deal in saltiness, color, cleanliness, and other respects. At times you are obliged to sell some of the poorer butter at a very low price and may even lose money on it. As a result of this lack of uniformity you are not able to pay any of these butter-makers as much as, perhaps, some of their produce is worth. By co-operation the farmers of this community could get together, thoroughly discuss the situation, and standardize their product. They would find out the kind of butter for which there was the greatest demand on the market and agree to manufacture all of their butter according to this standard. Butter not up to the required quality would not be marketed by the organization. By these methods the district as a whole would build up a reputation as a butter-making centre. You, as a dealer, and others would be willing to pay higher prices for butter from this district because you could depend upon

every pound being of high quality and exactly the same as every other pound. A further improvement could be made by the adoption of an attractive trademark and wrapper. (See page 231.)

The principle of standardization can be applied to the marketing of eggs, dressed poultry, and other farm products for the purpose of increasing the profits of the farmer.

Handling the Canadian Wheat Crop.—The disposal of Canada's annual wheat crop is a tremendous undertaking. The number of bushels handled each year is approaching the 400,000,000 mark. There are many classes and grades of grain, and each presents its own problems of marketing.

At the present time wheat may be sold through the Pool or a commission firm. In either case it must be shipped by the farmer to one of the terminal elevators at the head of the Lakes or at Vancouver.

The Methods of Shipping Grain.—The methods of shipping grain are as follows: Wheat may be hauled to town and sold to the elevator there in **wagon lots.** Grain sold in this way is called *street grain.*

(*a*) If the wheat is to be sold to a *line company*—that is, a commission firm operating on the Grain Exchange—the farmer and the elevator agent agree upon the grade of the grain, and the grain is paid for at the *street price* quoted for that particular day.

(*b*) When the farmer is a member of the *Pool,* he and the elevator agent agree upon the grade as before, and the farmer receives from the agent an initial payment, which is fixed by the Pool and sent periodically to the elevators. The farmer also receives a *grower's certificate,* in duplicate, stating the grade and number of bushels in his load. One copy of this certificate is sent to the Pool offices, and subsequent payments made by the Pool to the farmer are based upon the information contained therein.

Larger quantities or **carload lots** of wheat are handled in a somewhat different manner. The farmer may load his car through the elevator or over the platform, the procedure varying in some respects in each case.

(*a*) When the wheat is loaded by the farmer himself *over the platform,* he must first order a car from the station agent. When the car is in place the wheat is hauled to town and loaded. The car is then sealed and billed to a commission agent or the Wheat Pool. At Winnipeg the wheat is graded, and, when it reaches the head of the Lakes, it is weighed and unloaded into the terminal elevator, where it may be stored for 15 days free of charge. The commission agent then sells the grain according to instructions given him by the farmer. Within 24 hours after the wheat is sold the farmer must be sent a complete report of the sale. He is then forwarded the price received minus freight, or other charges against the grain, and the agent's commission. This method of loading the grain saves handling expenses at the elevator.

(*b*) Wheat may be loaded *through the elevator* in two ways: (1) *Special bin method.*—The farmer arranges for a special bin at the elevator, and the identity of his grain is thus preserved. He is allowed 15 days' free storage in which to haul in his wheat. As each load is brought in, it is weighed, and the farmer receives a *special bin ticket,* showing the weight of the grain in the load. He is charged $1\frac{3}{4}$ to 2 cents per bushel, which covers storage, handling charges, and insurance while his wheat is in the elevator. When enough to fill a car has been hauled in, it is loaded and shipped. If the farmer pays the above charges, he can ship his grain to any selling agency he wishes. But if these charges are not paid, the company owning the elevator ships the wheat to its own terminal elevator, sells it as ordered by the farmer, and sends him the price

received less freight, commission, and the above charges. (2) *Graded grain method.*—If the farmer does not wish a special bin, he and the elevator agent agree upon the grade and dockage of each load, and the farmer receives a *graded ticket* for every load. The ticket shows the net bushels of each load, the grade, and the dockage. By this method the farmer's wheat loses its identity. The grain of several farmers is unloaded into one big bin. Since the elevator can handle more grain with less trouble by this method, it is cheaper than special bins.

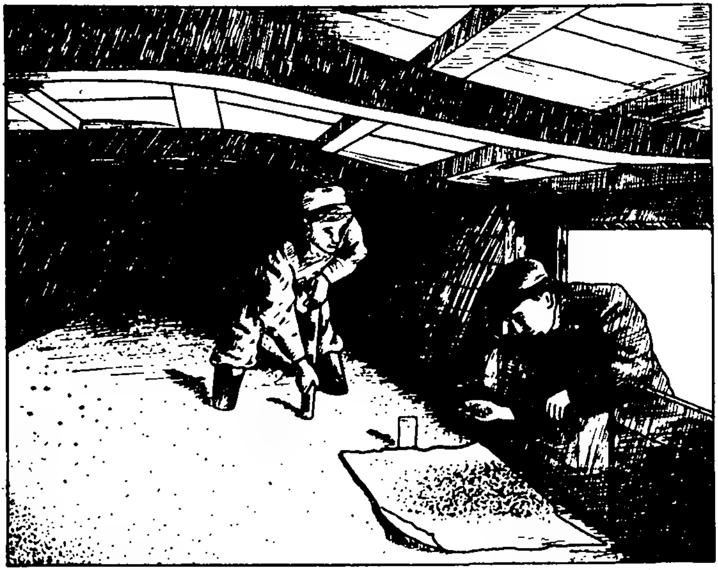
Grain is shipped by any of these methods whether sold through a line company or the Wheat Pool.

Spot and Track Wheat.—Wheat that is loaded and ready for transit is called *track wheat.* Grain unloaded in the elevator at Fort William or Port Arthur is known as *spot wheat.* Spot wheat is usually from one to three cents higher in price than track, because it is on hand ready for delivery, while track wheat is in transit and may be delayed and thus not available when required.

Exercise.—Make a chart showing the different methods of handling grain, as follows: At the left hand side of the page and half-way down neatly print the word *Wheat.* From the word draw four lines diverging so that one goes towards the top of the page, another towards the bottom, and the other two are spaced evenly between the first two. At the end of each of three of the lines draw a small elevator, and at the end of the fourth line a loading platform. On the line to the top elevator print *Wagon Lots, Street Wheat*; on another line print *Carload Lots, Special Bin*; on another, *Carload Lots, Graded Grain*; and on the line to the platform, *Carload Lots, Platform.* The diagram of the street grain is now complete because the grain is sold at the elevator, and the farmer has no more concern with it. From each of the other three diagrams—that is, two elevators and the platform—draw a short line, a railway car, then a short line, and print the words *Winnipeg, Grain Graded,* then a short line, and draw a diagram to represent a terminal elevator. On the railway cars print *Track Wheat,* and on the terminal elevators print *Terminal Elevator, Spot Wheat.* Now go back and rule all lines double, this time in a different

color. One color represents grain sold by a line company, and the other that sold by the Wheat Pool.

When you have finished the above directions, you will have a fairly complete diagram representing the four methods by which grain is shipped. The diagram can be made to show many more of



Courtesy of Dept. of Trade and Commerce, Ottawa.

Taking a sample of grain from a car, showing the sampler with his probe on top of the grain, the track foreman upon a ladder leaning over the door of the car, the cloth on which the grain is emptied, and the sample ticket.

the details by printing on it any other information that you wish, but it is not wise to try to show too much on one diagram. It would be better to draw other diagrams.

The Grading of Canada's Grain Crops.—Each car of wheat, on its way to the head of the Lakes, is stopped for a short time at Winnipeg. A gang of government men break the seal on the door, and remove a small sample from the car. The sample is taken by means of a long, slender,

pointed probe, which consists of two perforated metal cylinders, one fitting inside the other. The cylinders may be turned so that the perforations are opened or closed (similar to the top of a talcum powder box). A man enters the car and thrusts the probe, closed, vertically into the grain. The probe is then opened, to allow the grain to fill it, after which it is closed. In this way a sample is secured from the top to the bottom of the grain in the car. A

Courtesy of Dept. of Trade and Commerce, Ottawa.

Grading grain. The inspector at the left is examining the quality of a sample of grain, the next man is calculating the weight per measured bushel, and the last is putting the grain through sieves to determine the dockage.

similar sample is removed from various parts of the car, each being emptied upon a canvas at the door. When sufficient wheat has been taken to ensure a representative sample from the car, the grain on the canvas is thoroughly mixed, and a small bag filled. A tag bearing the number of the car is tied to the bag, which is then hung just outside the car door. It is the duty of a member of the gang to re-seal the car doors and gather the bags.

The grading is done by skilled government inspectors,

who have an office in the Grain Exchange Building. Each sample is carefully examined and compared with standard samples. The grain is also weighed to determine its *weight per measured bushel.* By means of sieves the percentage of weed seeds or *dockage* is determined. Finally, the grade is decided upon, and the sample is filed away to be available in case the farmer disputes the grade given. A report of the grade is sent to the commission firm to which the car is billed. Grading is also done at Calgary, and at the head of the Lakes or at Vancouver.

The Canadian Grades of Hard Spring Wheat

No. 1—Hard.
No. 1—Northern—60 per cent bread-making wheat, 60 pounds per measured bushel, clean and sound.
No. 2 to No. 6—Northern.
Feed.
No Grade—grain which is *tough* or damp and must be dried before being graded.
Condemned—heated or bin-burnt grain.
Rejected—wheat is rejected for unsoundness, smut, must, sprouted grains, weed seeds or other kinds of grain.

These grades may be combined as *No. 3 Northern—Tough,* or *No. 4 Northern—Rejected,* so that altogether there are some 30 grades of Hard Spring Wheat. There are also grades of Winter Wheat, Durum Wheat, and Kota Wheat.

NOTE.—Every school should have a copy of the bulletin *Grain Inspection in Canada,* distributed free by the Department of Trade and Commerce, Ottawa.

Spot, Track, or Street Wheat Distinguished from the Grades.—Spot, track, or street wheat must not be confused with the grades of wheat. These names are given to classes of wheat according to their location or the method by which they are being sold, and are not grades. Any of the grades of wheat in transit are track wheat, and any grade unloaded in the elevator at Fort William is classed as spot wheat.

Methods of Selling Wheat.—As before stated, grain may be sold by the farmer through the agency of the *Wheat Pool* or one of the *commission firms operating on the Grain Exchange.*

The Grain Exchange.—The Grain Exchange is an organization of men or companies engaged in buying and selling grain. There are exchanges at Winnipeg, Vancouver, Liverpool (England), Duluth, Chicago, Minneapolis, and other points. The members of these Exchanges make their business the selling of the farmer's grain, charging a commission of about one cent per bushel for their services.

The advantage of an Exchange to the farmer is that through it he can reach purchasers for his grain whom he could not otherwise get in touch with—for example, buyers from other countries. There are many who strongly contend that selling through commission agents on the Grain Exchange is still the cheapest method of marketing grain.

The features of the Exchanges that many farmers object to are as follows: The system allows speculation. There are middlemen whose profits reduce the net returns of the farmer. In selling through commission firms each farmer acts individually, and, when large numbers of farmers dispose of their wheat immediately after threshing, the market is flooded. The result of overloading the market in this way is to force down the price. As many farmers are forced by financial circumstances to sell their wheat early in the fall, they are obliged to accept the low price.

Cash and Future Markets.—All wheat is bought and sold for cash, but this is not the meaning of the term "cash wheat". *Cash wheat* is wheat bought or sold and delivered immediately. *Future wheat* is wheat purchased or sold but not to be delivered until a future date. November, December, and May wheat are classes of future wheat; that is, they have been sold probably early in the year to be delivered in November, December, or May.

The future market offers opportunity for speculation. For example: A man buys 2000 bushels of May wheat in the fall at $1.20 per bushel. He does not have to take delivery until the end of April. By April the price may rise to $1.35. Some time in April he sells. He bought at $1.20 and sold at $1.35—a profit of 15c. per bushel or $300. Of course, if the price had gone down before he sold, he would have had a loss instead of a profit.

Operations in the Pit of the Grain Exchange.—All buying and selling on the Exchange is carried on in the *Pit.* There the representatives of the companies who are members of the Exchange meet to buy and sell grain. The market opens at 9.30 o'clock in the morning and closes at 1.15 p.m.

To an observer, looking for the first time upon the Pit in operation, it appears to be a scene of great confusion and noise. But, if one observes carefully, it will be seen that the movements of the grain merchants are very efficiently organized. Each man upon the floor of the Pit calls in a loud voice the kind, grade, and number of bushels of the grain which he has for sale or desires to purchase. A series of signs, indicated by holding the hand and fingers in different positions, has been arranged so that the men can signal to each other through the noise. When an agent hears the kind of grain which he wants being called, he signals to the caller, and by signs they "put through" the sale. Each then notifies his office by means of messenger boys. These boys are travelling at top speed carrying communications back and forth from the office of the firm to their representative on the floor of the Pit. Along the wall are a number of telegraph instruments sending reports to and receiving reports from other exchanges. The reports are posted immediately upon large bulletin boards.

And so the market goes on throughout the morning. The price of each kind of grain rises and falls according to

the demand for it. If there are few buyers and large amounts for sale, the price will drop, or, when the supply is limited and the buyers are plentiful, the price will go up. Reports coming in from other parts of the world will also influence the price, so that it is almost impossible to know one minute what the price is going to be the next.

Exercises.—(1) From the market page of a daily paper or a farm magazine cut out the grain quotations and paste them in your book. Two price lists will be found, namely: the *cash list*, named "Cash Prices" or "Spot Prices", and the *future quotations*, called "Future Prices" or "Winnipeg Grain Fluctuations".

The future quotations will appear as:

Winnipeg Grain Fluctuations

Wheat	Open	High	Low	Close	Previous Close
May............	$147\frac{3}{8}$	148	145	$145\frac{1}{4}$	$147\frac{1}{8}$
July.......... ..	145	$145\frac{1}{2}$	$142\frac{5}{8}$	$142\frac{5}{8}$	$144\frac{5}{8}$
Oct.............	$129\frac{3}{8}$	$129\frac{7}{8}$	$127\frac{3}{4}$	128	$129\frac{3}{8}$
Oats					
May............	47	47	$46\frac{5}{8}$	$46\frac{5}{8}$	$46\frac{7}{8}$
Etc.					

The *open price* is the price when the market opened at 9.30 o'clock; *high* is the highest price during the morning; *low* is the lowest price; *close* is the price when the market closes at noon; and the *previous close* is the closing price of the day before.

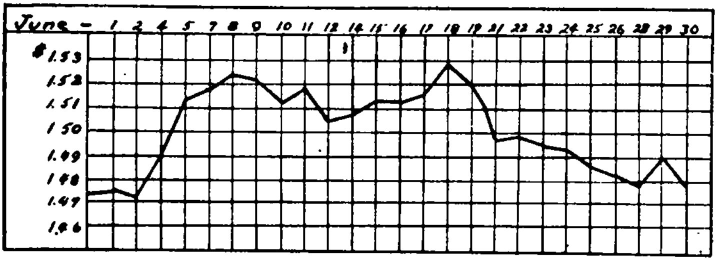
(2) Compare price quotations daily for a week and observe the fluctuation that occurs.

(3) Make a graph of the fluctuation in the price of one class of wheat—for example, May wheat, for a month or more. Secure a sheet of graph paper or rule a blank sheet into squares $\frac{1}{8}$ inch in size. Mark the days on a horizontal line across the top of the page, and the price along a vertical line at the left of the page. Each day locate the price at the proper place on the graph. Join the prices marked, and the resulting line will indicate the daily rise or fall in price. (See page 278.)

The Wheat Pool.—The Wheat Pool method of selling grain grew out of an attempt by the farmers to improve

certain of the conditions under which they were obliged to market their wheat. It was felt that, if a Pool was established, such an organization would be in a position each fall to advance its members an initial payment with which to meet obligations, and at the same time prevent the overloading of the market and a disastrous drop in prices.

A Wheat Pool is an organization of farmers who pledge themselves to deliver all of their wheat to the organization, sell it co-operatively, and pool or distribute the net returns

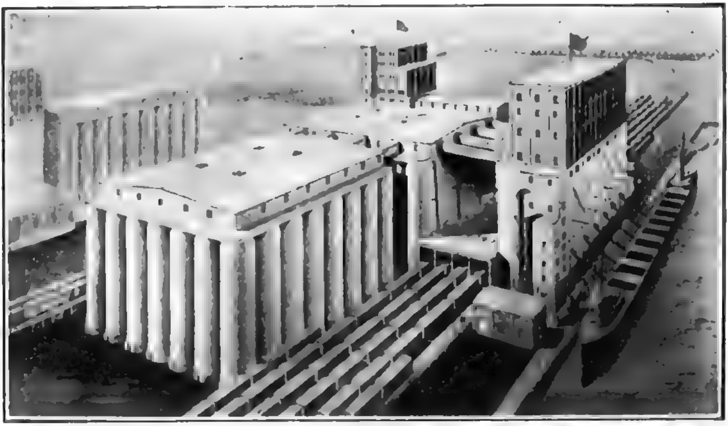


Graph showing the fluctuations in the price of July wheat during June, 1926.

among themselves in proportion to the amount and quality of the wheat which each has contributed. There is a Pool in each Prairie Province under the name of the *Manitoba, Saskatchewan,* or *Alberta Co-operative Wheat Producers, Limited.* The wheat of the three Provincial Pools is marketed by a *Central Selling Agency,* known as the *Canadian Co-operative Wheat Producers, Limited,* located at Winnipeg.

The features of the Wheat Pool are briefly as follows: The same price per bushel for the same grade for the same class of wheat is received by each member irrespective of the time that he delivers his grain—this is why the organization is called a Pool. The middleman is eliminated, so that a larger proportion of the proceeds from the sale of his wheat

is returned to the farmer. The Pool makes an initial payment when the grain is delivered, which enables the farmers to sell their grain in the fall and receive money with which to meet their financial obligations; at the same time, the Pool holds this grain in its elevators, places it upon the market gradually, and thus prevents the flooding of the market and a drop in prices. As the wheat is sold, the Pool makes further payments during the year until the



Courtesy of the Publications Branch, Regina.

A wheat pool terminal elevator at Port Arthur, Ontario.

full net value of the grain is paid. Because of the large membership, the Pool is able, at a very small cost per member, to employ high-salaried experts to direct its selling activities. A small charge (less than a cent per bushel) is made upon members for operating expenses —there is also a charge to cover the cost of purchasing or building elevators. Each member of the Pool signs a contract to deliver all of his wheat to the Pool for a period of years. The contract ensures the Pool management of a large volume of wheat each year.

Western Canada's Geographic Position and its Relation to World Markets.—The agricultural industry of Western Canada is in a peculiar geographic situation. It is many miles removed from the ultimate markets for its produce. Our wheat is sold chiefly in Great Britain, Southern European countries, the United States, and China. Great Britain is also one of our best markets for bacon, dairy products, eggs, and cattle. (See pages 186, 214, 223, 231, and 248.) In these markets we must face very keen competition from other countries. Denmark is a strong competitor for the bacon market of Great Britain, and Denmark is close to the British Isles. Our wheat, wool, mutton, and dairy products must compete with Australia and other countries which are located many miles from Britain, but which are able to ship their products by water, which is the cheapest means of transportation. The wheat and other farm produce of the prairies must be shipped many miles by railroad, which is much more expensive than water transportation.

Exercises.—(1) The importance of freight rates to the Western farmer is well illustrated as follows: Freight from points on the eastern boundary of Saskatchewan to the head of the Lakes is 17 cents per 100 pounds of wheat. From the western boundary of the province the rate is 27 cents per 100 pounds. Calculate the difference in the freight charge between western and eastern parts of the province on a 1500-bushel car of wheat being shipped to the head of the Lakes. (A bushel of wheat weighs 60 pounds.)

(2) Explain how Canada can dispose of her agricultural products to the best advantage on the markets of the world in competition with other countries. In your answer discuss fully such questions as co-operation, high-quality products, standardization, etc.

CHAPTER XVII

FARM MANAGEMENT—PART THREE

Planning the Farm and the Farm Home.—Not only is a well-planned farm a source of great satisfaction and pride to the owner, but every improvement in this respect adds to the value of the farm, and decreases the cost of operating it.

The Farmstead.—The farmstead, which refers to the grounds around the house, should be most carefully arranged. It is the home of the family as well as the business centre of the farm. Trees and flowers should be used liberally to make it as attractive as possible. If the buildings are kept freshly painted, not only is their life prolonged, but much is accomplished to improve the appearance of the farmstead. Many miles of useless travel may be saved by grouping such buildings as the horse barn, the implement shed, and the machine shop together. The house should not be too far from the well. It is desirable for the economical operation of the farm that the farmstead be situated near the centre of the farm, but for social reasons a location near a public highway has many advantages.

The Fields.—These should be of equal size as far as possible in order that a satisfactory rotation of crops may be carried out. Long fields are more economical than square ones, as less time is wasted turning at the ends when plowing or performing other operations. Which will be more expensive to fence? The fields should be arranged so that each one may be reached quickly from the farmstead. Much valuable time is often used up in travelling long distances to and from the fields.

Exercises.—(1) A 4-acre plot in the shape of a rectangle measures 20×32 rods. A square plot the same size is 25 rods 5 feet along each side. (*a*) Calculate the length of fencing required for each field. (*b*) A two-bottom gang plow turns over a strip of soil 28 inches wide. At the end of each strip a turn must be made. How many more turns are required to plow the square than the long one? (*c*) If it takes ¾ minute, on the average, to make each turn, how much more time is necessary?

(2) A farmer is feeding a number of steers for a period of 300 days. They require 20 bushels of grain per day. The granary is situated 15 rods from the barn. A man can carry 2 bushels each trip, travelling 3 miles per hour. (*a*) How many trips to the granary are required during the 300-day feeding period? (*b*) How many miles are travelled? (*c*) How much time is required? (*d*) What saving in time would be made by having the grain bin in the barn? (*e*) How much money would be saved at 20 cents per hour?

(3) Draw a plan of your home farm. On the drawing let 12 inches equal a mile. Locate all details.

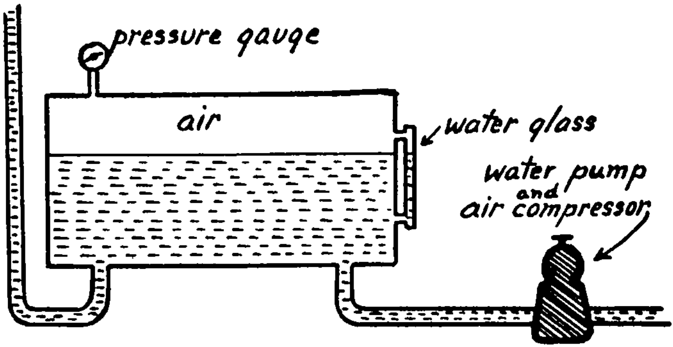
(4) Can you suggest any other arrangement of the fields or buildings that would reduce the time required to travel between them?

The Farmhouse.—The house should have the choicest position on the farmstead. A location on high ground is desirable in order that it may be dry at all times.

Great care must be taken in planning the house to make it comfortable, healthful, well lighted, and convenient. In the *rooms* consideration must be given to the size and location of the furniture. It is a good plan to arrange the doors and windows so that the furniture may be placed in several positions. In the bedrooms the bed should be away from outside walls. The head of the bed is best against an inside wall. Windows should be placed to prevent drafts across the bed. Small doors and windows are poor economy. A fireplace in the living room will prove a source of great satisfaction. As little space as possible should be used up in halls. These are difficult to heat in cold weather. Plenty of clothes closets should be provided. The kitchen must be carefully planned. It is

best located on the corner of the house to provide more light. Convenience is essential. Every effort should be made to reduce the number of steps which the housewife must take in preparing the meals; this may be done by having the dining-room and pantry doors close together and the sink, stove, and work-table conveniently located. A washroom with an outside entrance off the kitchen or dining-room will save a great deal of work.

The *basement* requires as careful planning as any other part of the house. The furnace should be located centrally.



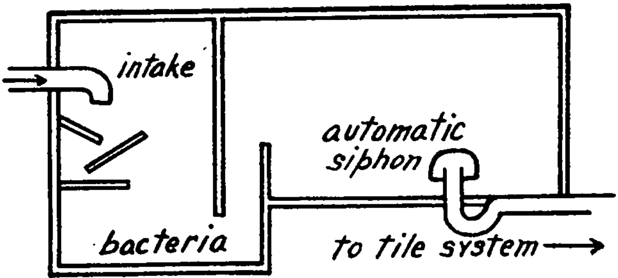
A pneumatic tank, to raise water to the upper floors of the farmhouse. (Draw.)

The chimney must not be too far away from the furnace. Arrangements should be made for coal and wood bins, for fruit and vegetable storage, for a soft-water cistern, a pneumatic tank, a lighting plant, and, if possible, for laundry space. A small gas engine in the basement, or in a nearby outhouse, can be used to pump water into the pneumatic tank, run the washing machine, turn the churn, operate the cream separator, and drive the lighting plant.

A *pneumatic tank* is cylindrical in shape and contains both air and water. When water is pumped in, the air is compressed in the top of the tank. This compressed air

exerts sufficient pressure upon the surface of the water to raise it to the upper floors of the house.

Where a water system is established and considerable water used, a *septic tank* is necessary to dispose of the sewage. These tanks comprise two compartments, in which gather certain forms of bacteria. In the first compartment the solid part of the sewage is reduced by the bacteria to a



A septic tank, for the disposal of sewage on the farm. (Draw.)

liquid. It then passes into the second compartment, from which it is discharged at intervals by an automatic valve or siphon into a series of tiles. Through the tile system it soaks away into the ground. As it finds its way through the tile and soil, the water from the septic tank becomes purified. The tile and the tank must be buried deep enough to prevent freezing during the winter.

The *well,* from which the drinking water is drawn, should not be located below the tile system of the septic tank or where seepage from the barns may soak into it. A good supply of pure water is an essential to every farm.

Soft water from the roof should be stored in galvanized iron or cement tanks. If it is filtered before it enters the tank and the tank is kept tightly covered, the water will not as readily become dark colored or foul smelling. Even the flavor may be kept fresh in this way if it is necessary to use the soft water for drinking purposes.

Herbaceous Perennial Flowering Plants.—These are plants with soft juicy stems, which die down to the ground each fall and grow up again from the root the following spring. When planted from seed, they do not usually produce flowers the first year; but, once established and given a reasonable amount of care, they produce a profusion of bloom each year and should have a place in every garden.

They require an open sandy loam that will not readily become hard or baked. The soil should be thoroughly prepared and enriched with well-rotted manure before the plants are set out. A southern exposure, in full sunlight, and, if possible, well protected from the wind, should be selected. Many perennials may be grown from seed started early in-doors in shallow boxes, and transplanted into the garden when the danger of frost is over, usually about June 1st. Very satisfactory results are obtained by securing young plants or roots from reliable nurseries. Many perennials are propagated by root division. When this method is followed, planting is done in the late fall or early spring. Taller varieties should be placed at the back of borders or in the centre of beds. Masses of the same color produce the most attractive effect. An arrangement should be planned that will provide a continuous abundance of bloom throughout the entire growing season.

During the summer the soil must be raked or hoed occasionally to control the weeds and conserve moisture. Blossoms, as they wither, are removed. In the fall, after the ground is well frozen, the plants should be covered with about 4 inches of strawy manure or leaves. This blanket is left on until the spring season of alternate thawing and freezing is over. This time of the year is even harder on the perennials than the winter. The coarse material is then raked off, and the fine part is thoroughly dug into the

soil around the plants. Some of the hardy perennials are: hollyhocks, columbines, larkspurs, pinks, bleeding hearts, iris, peonies, golden glow, spirea, poppies, and many others. Bulbs, such as tulips, are useful for early blooming, and are followed later by geraniums or similar plants from the greenhouse.

Annual Flowering Plants.—Many varieties of annual flowers are better started in-doors and transplanted later into the garden. The seed should be planted in shallow boxes early in April. The soil used must be well enriched, thoroughly pulverized, and quite sandy. Why is a good supply of sand necessary? Most flower seeds are very small. They are sprinkled on the surface of the soil and gently pressed in by using a board. A very thin covering of fine soil may be sprinkled over them. Many failures with flowers are caused by covering the seeds too deeply. The boxes must be kept in the sunlight as much as possible to prevent the young plants from growing too quickly and becoming spindly. Transplanting in the garden should be done about June 1st.

The soil in the garden should be deeply enriched with well-rotted manure. It should be thoroughly raked to pulverize the lumps and to provide an even level surface. Plenty of room must be allowed for each plant to develop. There are several varieties of annuals that may be started outside from seed. The same care must be exercised in the garden to avoid covering the seeds too deeply. As the plants grow, they may be thinned gradually until they are the desired distance apart. Annuals may be used to fill gaps in the perennial borders, or in beds by themselves. The same general rules in regard to color and size are followed. Some easily grown and showy annuals are: poppies, asters, petunias, mignonette, nicotiana, verbenas, stocks, alyssum, calliopsis, and a host of other well-known varieties.

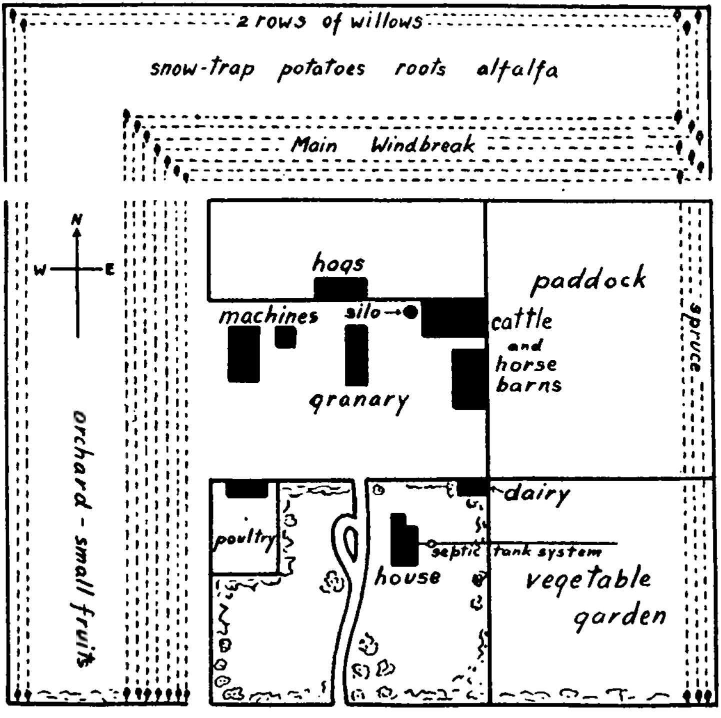
Trees and Shrubs for Shelter Belts and Ornamental Purposes.—*The value of trees.*—Too many houses and schools are to be seen in country and city without a tree or bush of any kind to relieve the harsh outline of the building or break the monotony of the prairie. Why should these conditions continue to exist? Trees can be made to grow almost anywhere if a little attention and care is given them. The expense is very small. *The Dominion Forestry Branch has established Nursery Stations at Indian Head and Sutherland, Saskatchewan, and will supply trees for windbreaks, free of charge, to any farmer or school in the three Prairie Provinces.* All that the government requires is a thorough preparation of the soil in which the trees are to be planted and a guarantee that the trees will be well cared for after planting. *For information concerning tree-planting or free distribution of trees, write to the Chief of Tree Planting Division, Dominion Forestry Nursery Station, Indian Head, Saskatchewan.*

The value of trees may be briefly summed up as follows: Buildings, crops, and live stock are sheltered from the wind. Shade is provided. The home and its surroundings are made more attractive. Humus is restored to the soil. Soil-drifting is reduced. Birds are attracted. Firewood and fencing material are produced. The snow is held back from the buildings during the winter. Finally, because of their many advantages, trees greatly increase the value of the farm.

The location and arrangement of the trees.—This must be given very careful consideration because, once the trees are established, they cannot readily be moved. Windbreaks should be heaviest on the side of the farm most exposed to storms, usually the north and west. Rows of trees are better placed at least 30 yards away from permanent buildings to prevent the drifting and piling of large quantities

of snow around the buildings. *The Forestry Branch will not supply trees for closer planting.* Individual trees should be planted where they will appear to the best advantage.

It is recommended that shelter belts should contain from 5 to 7 rows of trees, the rows being placed 4 feet apart



A plan of a farmstead. The following is suggested as a good arrangement of trees in the main shelter belt: two outside rows of caragana, a row or two of ash or elm, two rows of poplar and Manitoba maple planted alternately in the rows, a row of willows, and 10 or 15 feet in from the willows a couple of rows of spruce or pine. (Draw.)

and the trees spaced at intervals of 4 feet in the rows. If the windbreak is more than from 5 to 8 yards wide, the trees are frequently broken down by the weight of the great

volumes of snow trapped. To prevent this, a single or double row of trees is frequently planted about 30 yards out from the main belt to form a *snow-trap* and hold back some of the snow.

Preparation of the soil.—The soil must be very thoroughly prepared before the trees are set out. It is essential to make the soil loose and porous, to destroy all weeds and grasses, especially the latter, and to conserve an abundant supply of moisture. Land under cultivation should be summerfallowed or used for inter-tilled crops for two years previous to the time of planting. New land should be broken early in the spring, backset later in the summer, and well cultivated for the remainder of the season, then thoroughly summerfallowed during the second year.

Planting may be done either before or after the growing season, while the trees are dormant, but only spring planting gives sure results. Small trees are more satisfactory than larger ones. Great care must be taken to prevent the roots of seedlings, especially evergreens, from drying out. They should be planted as soon as possible after being received from the nursery. If this cannot be done, a good plan is to *heel in* the seedlings. A trench is dug, the roots are placed in it, and the soil is thrown back to cover the roots. It is necessary to pack the soil and keep it moist. Why? When planting, the seedlings may be carried in a pail of thick, muddy water. All broken or injured roots of the larger trees should be trimmed off with a clean, sharp knife. Tops of deciduous trees must be pruned to balance the reduced root system. After the trees are in place, the soil should be thoroughly packed by tramping to press it around the roots and prevent it from drying out.

When large numbers of seedlings are being set out, a deep furrow may be opened by a plow. Care must be taken not to open the furrow too far ahead of the planter. Why?

Immediately following the plow, the trees should be placed in position, the soil thrown over the roots, and well tramped. A sharp stick or dibble may be used to open the soil for cuttings, which are best planted in a slanting position and quite deep, with the buds pointing up. (See page 109.)

The first planting was done around this farm home in 1911. Previous to that time the site was bare prairie. Notice the splendid growth of both evergreen and decidous trees. The photograph was taken in 1925.

In planting individual trees or shrubs the hole should be made large enough to allow the roots to be well spread out. A part of the surface soil may be placed in the bottom of the hole, and the remainder used to pack around the roots. As the hole is being filled in, the soil may be thoroughly soaked with water. This assists in getting the soil well worked in between the roots, but, if the soil is watered, it should not be tramped. Tramping at this time would pack it into a hard mass very injurious to the growth of the roots. A small quantity of dry soil should be saved and

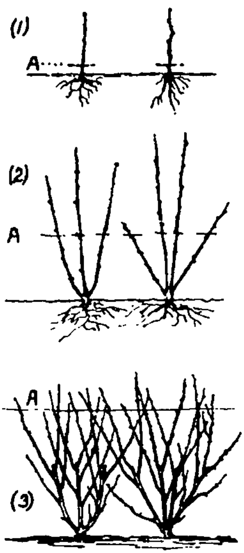
spread over the moist soil to form a mulch. What is the value of doing this?

Care after planting.—Trees require a great deal of very careful attention after planting, if the best results are to be obtained. For three years at least, or until the trees are well established and large enough to prevent foreign growth by their shade, thorough cultivation must be carried on between the rows. Give two reasons. Windbreaks should be carefully watched for the appearance of disease or insect pests, and steps immediately taken to control these if necessary. The Forestry Branch Nursery Stations at Indian Head or Sutherland will supply, free of charge, a bulletin dealing with the control of insects that attack shade trees. Branches that are broken by the wind or snow require to be removed, and the wounds must be trimmed, if jagged, and treated to prevent the entrance of disease germs. (See section on pruning, page 105.) The trees should be fenced to protect them from live stock. Thinning is required to prevent overcrowding as the trees grow, but it has been found at the Indian Head Nursery Station that it is not necessary to prune or thin out trees in shelter belts until the belt is about 20 years old.

Suitable varieties. — Windbreaks of mixed varieties usually give the best results. All trees are not subject to the same disease or insect pests. Some of the varieties used are: *caragana, Russian willow, Russian poplar, Manitoba maple, white* or *American elm, green ash, white spruce,* and *Scotch pine.* The caragana is most recommended for the outside rows, as it possesses several outstanding advantages over either the willows or poplars for this purpose. It is not advisable to plant ash or elm between rows of willow, poplar, or Manitoba maple. These latter, fast-growing trees, suppress and retard the growth of the slower varieties. Such native trees as the *wild plum* and

pin cherry usually give very satisfactory results when they can be obtained. Western-grown trees should be used whenever possible. Write to Indian Head, Sutherland, or the Experimental Station at Morden, Manitoba, etc., for information about the best varieties of honeysuckles, lilacs, and other ornamental shrubs.

Hedges.—The same care is essential in the establishment of a hedge as in the setting out of trees or shrubs for windbreaks or ornamental purposes. Similar methods are used in planting and in subsequent attention. The soil should be thoroughly prepared before the plants are set out. An effort must be made to train the hedge into a dense, compact row. This may be accomplished by careful pruning each year (see page 105) to cause the plants to branch more freely. Spruce and caragana are two of the most satisfactory hedge plants. The caragana is most commonly used. It may be started from one-year-old seedlings or from seed. The seed is planted, in the fall or very early in the spring, in rows about $\frac{3}{4}$ inch deep and from 10 to 12 seeds per foot.



Courtesy of Forestry Branch Nursery Station, Indian Head.
Starting a caragana hedge. (1) One-year-old seedlings just planted, one foot apart, should be cut off one inch from the ground at line A. (2) The following spring 6 or 8 inches of the previous season's growth should be cut back to line A. (3) The third spring it should be trimmed back to line A before the leaves begin to grow.

Projects.—(1) If a windbreak has not already been established around the school or around your home, make arrangements to plant one. Send to Indian Head or Sutherland for advice about your particular problems.

(2) If grass and weeds have been allowed to grow up between the trees in the shelter belt around the school or around your home, start a compaign to destroy these tree enemies, and put the windbreak in good condition again.

Lawns.—The lawn that is not too much cut-up is the most attractive type. The soil should be well prepared and thoroughly enriched before the seed is sown. The seed of many of the best grasses is very small. The surface of the ground should be made perfectly level. Care must be taken to have the seed bed solid, so that no hollows will result later through uneven settling of the soil. Seeding should be done as soon as the ground is well moistened with spring rains. For small lawns the seed is best sown broadcast over the surface of the soil, first lengthwise, then crosswise, and raked in with a fine-toothed garden rake. After sowing and raking, the ground should be packed with a light roller to press the soil around the small seeds.

When fineness of grass is desired, a good seed mixture is 35 per cent Kentucky blue grass, 35 per cent Canadian blue grass, 25 per cent red top, and 5 per cent white Dutch clover. The clover is better sown separately. Where a coarser, better-wearing lawn is required, such hardy grasses as western rye or brome grass could be substituted for part of the Kentucky or Canadian blue.

Once established, the lawn must receive considerable attention to keep it at its best. It requires to be clipped frequently, and the cut grass removed each time. Every fall a top dressing of well-rotted manure is advisable. The coarse material is removed in the spring and the finer carefully raked in around the roots of the grass plants. Special grass fertilizers may also be used. For this purpose pulverized sheep manure is very good. (See also page 22.) When spots in the lawn become bare, the soil should be loosened with a rake and reseeded. A light coating of fine, loamy soil should then be applied and rolled firm.

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